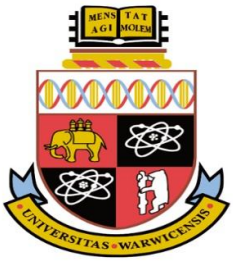

INNOVATION IN MIDDLE-INCOME AND HIGH-INCOME COUNTRIES: A COMPARATIVE STUDY OF INDONESIA AND UK MANUFACTURING FIRMS

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It is entirely my own work and has not been submitted in any previous application for any degree.

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ABSTRACT

This PhD thesis aims to investigate innovation activities in developing and developed countries and it comprises three papers. More specifically, it compares innovation activities between manufacturing firms in Indonesia and in the UK. The first paper (Chapter 2) aims to identify and compare the variations in the knowledge sourcing strategies (KSS) employed, and innovation barriers faced, by manufacturing firms in high-income (HI) and middle-income (MI) countries by using global innovation data derived from the UNESCO Institute of Statistics (UIS). The paper shows that manufacturing firms in HI and MI income countries have different types and levels of KSS. Knowledge from internal R&D is sourced more frequently by manufacturing firms in HI countries than by their counterparts in MI countries. While external knowledge from government or public research institutes; conference, trade fairs and exhibitions; scientific journals and trade/technical publications are sourced more frequently by manufacturing firms in MI countries. This paper also reveals that manufacturing firms in MI countries face greater innovation barriers internally and externally than those in HI countries. Internally, manufacturing firms in MI countries face greater obstacles related to costs/funding and knowledge. Externally, firms in MI countries face greater constraints related to costs/funding, knowledge, the market and other reasons in regard to not innovating than their counterparts in HI countries. Lastly, innovation policy implications are drawn from this paper.

The second paper (Chapter 3) investigates and models the innovation value chain (IVC) that encompasses knowledge sourcing, transformation, and exploitation activities among Indonesian manufacturing firms by using data from the Indonesia Innovation Survey (IIS) 2011. This paper is different from the previous IVC studies in a number of ways. First, in this study a range source of knowledge (i.e. R&D activities, informal interactions with various external actors, and formal cooperation with various external partners) is tested. Second, the relationship between a wide range of innovation barriers and the IVC, which to date has received little attention, is also investigated. Lastly, wider innovation (i.e. organisational and marketing innovation) is assessed. The study finds the existence of a synergistic relationship between internal and external sources of knowledge as well as among external sources of knowledge in the first link of the IVC. In terms of the second link of the IVC, internal R&D plays an important role that positively influences knowledge transformation into all types of

innovation and innovation success. External knowledge that has a similar pattern in shaping innovation mainly comes from market/commercials (i.e. customers and competitors), open sources (i.e. events) and formal cooperation with suppliers. Scientific institutions tend to contribute to innovation in a negative manner, and few positive impacts on process innovation are observed from government R&D and non-profit R&D institutions. The study also finds that informal knowledge is more strongly associated with innovation and innovation success than formal knowledge. Both informal knowledge and formal cooperation are more likely to influence traditional innovation (i.e. product and process innovation) than wider-innovation (i.e. organisational and marketing innovation). In general, the hampering factors with regard to innovation are financial and knowledge factors. Striking findings in the last link of the IVC are innovation new to the market, innovation new to the firm, and innovation success do not lead to the firms' performance. Lastly, relevant innovation policies are drawn from this paper.

The third paper (Chapter 4) compares the IVC which consists of knowledge sourcing, transformation, and exploitation performed by Indonesian and UK manufacturing firms. This study is worthwhile for the following reasons. First, despite comparative studies on the IVC not being new to the literature, it is interesting to understand and compare the IVC between developing and developed economies as up to now, this has not been done. This study provides a new insight on a micro-level analysis of the IVC comparison between developing and developed countries by modelling which specific knowledge is sourced by firms, the impact of the sourced knowledge on innovation, and the impact of innovation on firms' performance. Second, this study investigates a broader source of knowledge that is classified into R&D activities, informal knowledge and formal cooperation. Third, implementing traditional innovation in isolation has been criticised, and hence, in this study the impact of knowledge transformation on both traditional and wider innovation as well as the exploitation of both types innovation on firms' performance is tested. In terms of the first link in the IVC, for both countries, synergistic relationships exist within and between each group source of knowledge (i.e. R&D, informal knowledge and formal cooperation). However, the nature of these complementarities tends to differ across the two countries. In regard to the second link in the IVC, in UK firms, both internal and external R&D appear to have a direct impact on innovation. While for Indonesia, the positive and significant impact of internal R&D on diverse types of

innovation is stronger than that of external R&D; informal knowledge sourced from market/commercials makes a greater contribution to innovation and innovation success for Indonesian firms than UK firms. By contrast, formal cooperation provides a greater contribution to innovation for the UK than for Indonesia. However, such cooperation is more likely to be conducted with market/commercials network. In terms of the last link in the IVC, there is no single positive and significant contribution in terms of the link between product innovation (including new to the market and firm innovations) and firms' performance, or between innovation success and firm performance in either country. In addition, for both countries, different types of innovation affect firms' performance differently. For Indonesian firms, both traditional and wider innovation positively and significantly impact firms' performance, while for UK firms only traditional innovation that has such effect.

Keywords: innovation activities, manufacturing firms, Indonesia, the UK

LIST OF ABBREVIATIONS

CIS	Community Innovation Survey
GERD	Gross domestic expenditure on research and development
GDP	Gross Domestic Product
GNI	Gross National Income
HI	High-income
IIS	Indonesia innovation survey
INNBAR	Innovation barrier
INOVSUCCESS	Innovation success
ISIC	International Standard Industrial Classification
IVC	Innovation value chain
KSS	Knowledge sourcing strategy
K-S	Kolgomorov-Smirnov
MI	Middle-income
MKTGINOV	Marketing innovation
MWU	Mann-Whitney U
OECD	The organisation for economic cooperation and development
OLS	Ordinary least squares
ORGINOV	Organisational innovation
PPP	Purchasing Power Parity
PRODINOV	Product innovation
PROCINOV	Process innovation
R&D	Research and development
UIS	UNESCO Institute for Statistics
UKIS	United Kingdom Innovation Survey
UK SIC	UK Standard Industrial Classification
VIF	Variation inflation factors

CHAPTER 1 INTRODUCTION

1.1. Introduction

This chapter presents the introduction to this thesis and consists of research background, research questions, and structure of this thesis. The research background contains research motivation for writing three papers that make up this thesis. The first paper is a comparison study on knowledge sourcing strategy (KSS), innovation barriers and innovation outputs between manufacturing firms in the high-income (HI) and middle-income (MI) economies. The second paper investigates the innovation value chain (IVC), which encompasses knowledge sourcing, transformation, and exploitation among Indonesian manufacturing firms. The third paper compares the IVC between Indonesia and United Kingdom (UK) manufacturing firms.

1.2. Research Background

It has become widely acknowledged by innovation scholars that knowledge is an important prerequisite in innovation and the most important source of competitive advantage for a firm. Necessary knowledge use for innovation can be accessed from internal, external, or a combination of internal and external sources. A knowledge sourcing strategy (KSS) is defined as "a firm's approach to generating incoming knowledge flows through knowledge creation or knowledge acquirement" (Wen Lin and Hung Wu, 2010, p.582). Traditionally, internal research and development (R&D) is viewed as the primary source of knowledge generation (Rothwell, 1992). Internal R&D is widely implemented and well-appreciated approach for creating new knowledge, especially for firms operating in developed or high-income economies (Hobday, 2005), knowledge generation approach now moving up from 'research and develop' to 'connect and develop' (Houston and Sakkab, 2006). Previous studies have linked KSS with various topics such as complementary versus substitution KSS (e.g. Cassiman and Veugelers, 2006; Vega-Jurado et al., 2009), making or buying decision in regards to KSS (e.g. Veugelers and Cassiman, 1999), KSS as part of the innovation process (e.g. Battisti and Stoneman, 2013; Roper et al., 2008), KSS and absorptive capacity (e.g. Grimpe and Sofka, 2009), and the link between KSS and regional innovation system and policy (e.g. Roper et al., 2010; Tödtling et al., 2011).

Factors that influence KSS decision vary, and one of them is the innovation barrier that come from internal and/or external firms' environment that may hinder innovation activities. However, only a few studies that link KSS with innovation barriers, with the exception of Fu et al., (2015) and Keupp and Gassmann (2009) which investigate KSS (i.e. open innovation) against the innovation barrier. Due to the lack of adequate resources and capacities, as well as an increase of internal R&D costs and risks, many Chinese firms are not able to perform innovation activities alone, and as a result most of them decided to

source external knowledge and resources (Fu et al., 2015). However, these studies focus on a single country and use firm-level innovation data.

Previous innovation barrier studies largely focus on two topics, namely the factors affecting perceptions of the importance of barriers, and the impact of financial constraints on the propensity to innovate and/or the intensity of innovation (D'Este et al., 2012). Such focus allows for an opportunity to study KSS and innovation barriers from a different point of view. The first paper of this thesis intends to narrow this gap by linking KSS and innovation barriers that involve a wider number of countries and use aggregate firm-level innovation data or country-level innovation data which is derived from recent global innovation data provided by the UNESCO Institute for Statistics (UIS) which was launched in 2013.

The first paper links and compares KSS, innovation barriers, and innovation outputs between manufacturing firms in high-income (HI) and middle-income (MI) countries. Regarding KSS, Hobday (2005) argues that R&D activities differentiate between firms in HI and MI countries. Advanced R&D tends to be placed at the centre of innovation by firms in HI countries. Firms in MI countries tend to face barriers that prevent them from performing R&D activities, such as low levels of education attainment, the business environment, and the information infrastructure (Aubert, 2005). Therefore, findings are expected to contribute new empirical evidence on how firms from differently economically developed background performing KSS, facing internal and external constraints, and producing innovation outputs. It is also expected that the design of future innovation policies and strategies that are able to address hampering factors related to KSS, which prevent manufacturing firms across HI and MI countries from engaging in innovation activities will be formulated.

Focusing on firms' KSS may not provide a complete picture of the innovation process that may encompass some stages or activities. Hence, it may be worthwhile to conduct a further study that provides insight on the innovation process that is started by performing KSS, through knowledge transformation into diverse innovation, to knowledge exploitation that contributes to firm's performance. In innovation management literature, the innovation process that consists of the three activities is referred to the innovation value chain (IVC). The IVC concept, as coined by Hansen and Birkinshaw (2007, p. 122) views innovation as "a sequential, three-phase process that involves idea generation, idea development, and the diffusion of developed concepts". For firm's managers, IVC can be a useful tool used for detecting the strong and weak links in the innovation process. The links of IVC are interdependent, which means that if any links fail or is weak, it will affect the whole innovation process, regardless of the strengths of the other links (Hansen and Birkinshaw, 2007).

Empirical insights into IVC study mainly firms in advanced economies, for example, firms in North America and Europe (Hansen and Birkinshaw, 2007), Ireland (Doran and O'Leary, 2011; Roper et al., 2008), and the UK (Battisti and Stoneman, 2013; Ganotakis and Love, 2012; Love et al., 2011). Most of these studies use data derived from innovation surveys, with the exception of Hansen and Birkinshaw's

(2007) study. IVC links in these studies commonly consist of knowledge sourcing, transformation, and exploitation. Although these studies provide important evidence on the positive and causal links from knowledge sourcing, through knowledge transformation, to knowledge exploitation, limitations of the studies have been identified. *First*, IVC evidence in the context of developing countries to date has received little attention. *Second*, knowledge sources tested in existing IVC studies mainly are from internal R&D and informal knowledge such as customers, suppliers, competitors, and public R&D. *Third*, knowledge sources tend to be linked with technological innovation, such as product and process innovation, while non-technological innovation such as organisation and marketing innovation are less studied. Hence, there is a research gap in the study of IVC in developing countries, and this gap can be filled by involving wider sources of knowledge as well as wider different types of innovation. Based on the research gap, the second paper of this thesis aims to study the IVC in the context of a developing country (i.e. Indonesia) which currently has not been investigated.

Currently, no study has looked at innovation activities beyond case studies based on large scale survey data on IVC that consists of knowledge sourcing, transformation, and exploitation as well as factors that help and hinder innovation processes in Indonesian manufacturing firms. Existing innovation studies in the context of Indonesia that may be relevant to the study of IVC are fragmented, limited to specific industries and use case studies as the research method[1].

The second paper extends the concept of IVC in the context of Indonesia, which naturally may differ from previous IVC studies in developed economies. Hence, findings from the second paper are expected to provide a deeper understanding of how Indonesian manufacturing firms source knowledge, transform codified knowledge into diverse types of innovation, and profit from knowledge exploitation. It is also expected that IVC measurement can be used as a basis to support any relevant innovation strategies and policies that involve the connection of the three main activities of IVC. Innovation data used in the second paper is derived from the Indonesia Innovation Survey (IIS) of 2011. Indonesia innovation data is relatively new and has not been explored in academic research.

Indonesia is predicted to be one of the emerging economic giants along with three other developing countries, well known as MINT (Mexico, Indonesia, Nigeria and Turkey), to be the ninth largest in the world by 2050 (BBC, 2014). To achieve this, Indonesia needs to learn from other countries' experiences. In relation to IVC, conducting a comparison of IVC in Indonesia with that in developed economies, such

[1]See for examples the studied on the role of academia as external source of innovation in Indonesian automotive industry (Aminullah and Adnan, 2012); collaboration and innovation adoption in small-scale industry clusters (Sandee and Rietveld, 2001); innovation and information flow in small-scale cottage industries in a rural area (Kristiansen, 2002); sources of knowledge in small furniture industries (Van Geenhuizen and Indarti, 2005); social network and innovation of SMEs in handicraft industries (Brata, 2011); and innovation and cooperation activities of SMEs in food processing industry clusters (Najib and Kiminami, 2011).

as the UK, may generate important insights into the knowledge infrastructure for Indonesian firms which can be used to catch-up with the capabilities of other countries.

Despite the optimism surrounding the future of Indonesia, the country faces multiple challenges that may hinder innovation capabilities. The country has relied on, to a large extent, the export of natural resources and good trade links with leading global economies, and so has not developed a technology-intensive industry structure. Instead the country imports high-technology products outweighing exports (OECD, 2013). The largest contribution to growth has been made by non-IT capital (OECD, 2013). Further, government policies that prioritise the development of an adequate scientific and technological base tend to neglect developing the framework conditions for innovation (OECD, 2013). By contrast, the UK innovation system has different characteristics compared to Indonesia, which include "a genuinely world-leading science base and information structure; a major financial sector that can be better directed to support firm growth; a strong supply of high-level skills and access to globally mobile skills; and strong business performance in the creation of intangible assets" (BIS, 2013, p.4). These contrasting characteristics naturally may lead to variations in knowledge sourcing, transformation, and exploitation between firms in Indonesia and those in the UK.

Furthermore, to date, comparison of IVC between firms in developing and developed economies has not been conducted. Hence, it is expected that the third paper will provide new insight into the micro-level analysis of IVC comparison between developing and developed countries, highlighting which specific knowledge is sourced by the firms, the impact of the sourced knowledge on innovation, and the impact of innovation on firms' performance.

Aside from the research background, the three papers share similarities that lead to them being connected by this thesis. *First,* the three papers cover similar research topics, i.e. how different types of knowledge are sourced, then transformed into different types of innovation, and how innovation impacts firm performance. In the first paper, a country-level innovation data was used, which is different to the methods used in the second and the third papers. *Second,* the three papers employ the same innovation data derived from innovation surveys in developing and developed countries. *Third,* the three papers focus on manufacturing firms in developing and developed countries.

1.3. Research Questions

Based on the research background in the previous section, the following are research questions to be raised in each of the three papers.

1.3.1. The first paper

1. What is the difference in KSS performed, and innovation barriers faced, by manufacturing firms across HI and MI countries?

1.3.2. The second paper

1. To what extent are the various knowledge sources used by Indonesian manufacturing firms?
2. To what extent are the various knowledge sources used in the knowledge transformation activities associated with diverse types of innovation?
3. To what extent do the different types of innovation adopted by Indonesian manufacturing firms influence firm performance (that is proxied by productivity)?

1.3.3. The third paper

1. To what extent are knowledge sourcing, transformation, and exploitation performed differently by Indonesian and UK manufacturing firms?

1.4. Structure of the Thesis

This PhD thesis is comprised of five chapters. Chapter one, Introduction, describes the background of the study and presents the objectives and questions the research hopes to address. Chapter two, Paper 1, compares KSS, innovation barriers and innovation outputs among manufacturing firms in HI and MI countries by using global innovation data at a country-level, with data derived from the UNESCO Institute of Statistics (UIS).

Chapter three, Paper 2, investigates IVC which is comprised of knowledge sourcing, transformation, and exploitation links performed by Indonesia manufacturing firms. The paper employs innovation data derived from Indonesia Innovation Survey (IIS) 2011, which covers 2009-2010. Chapter four, Paper 3, compares IVC that encompasses knowledge sourcing, transformation and exploitation activities performed by Indonesian and UK manufacturing firms using innovation data derived from the IIS 2011 and the UK Innovation Survey (UKIS) 2011. The final chapter (Chapter 5), Discussion and Conclusions, summarises key research findings, empirical and practical contributions and relevant innovation strategies and policies.

CHAPTER 2 – PAPER 1

KNOWLEDGE SOURCING STRATEGIES AND INNOVATION BARRIERS ACROSS MANUFACTURING FIRMS IN HIGH- AND MIDDLE-INCOME COUNTRIES

2.1. Introduction

Innovation plays a crucial role in the competitiveness and economic growth of a firm and a country. Successful innovation depends not only on firms' internal competencies but also on their ability to absorb external information, knowledge, and technologies (e.g. Cassiman and Veugelers, 2006; Roper et al., 2010; Segarra-Blasco and Arauzo-Carod, 2008), and "even the largest and most self-contained of organisations requires information from beyond its boundaries" (Veugelers, 1997, p.303). Therefore, searching for new ideas to solve firms' existing problems increasingly goes beyond the firm boundaries in order to explore other institutions' capacities (Vega-Jurado et al., 2009). However, firms' search strategies critically rely on their ability to recognise and exploit external knowledge to be used in the innovation process, as the concept of 'absorptive capacity' highlights (Cohen and Levinthal, 1989, 1990). In addition, nowadays, the innovation process is viewed as a highly interactive process, and as a result, firms tend to rely on both internal and external knowledge (Tödtling et al., 2011). Consequently, a critical issue for firms is to determine and balance the sources of knowledge that most influence their innovation output and innovation performance, i.e. whether it comes from internal or external sources or both, as well as any factors that hinder their knowledge sourcing strategies (KSS).

KSS is defined as "a firm's approach to generating incoming knowledge flows through knowledge creation or knowledge acquirement" (Wen Lin and Hung Wu, 2010, p.582). According to Roper et al., (2008) the main part of the knowledge sourcing activity consists in assembling the different types of knowledge used for innovation. "Firms may interact via various ways to access knowledge outside their boundaries" and "interaction is a key concept for knowledge creation and innovation" (Caloghirou et al., 2004, p. 29). Therefore, firms strongly rely on networks, collaboration and partnerships in which they are able to access resources, knowledge and information, which is then circulated rapidly at low cost (Chesbrough and Teece, 1996).

Previously conducted-KSS studies have focused on complementarity versus substitution (e.g. Cassiman and Veugelers, 2006; Vega-Jurado et al., 2009), make or buy dilemma in regard to KSS (e.g. Veugelers and Cassiman, 1999), the role of KSS as part of the innovation process (e.g. Battisti and Stoneman, 2013; Roper et al., 2008), the relationship between KSS and absorptive capacity (e.g. Grimpe and Sofka, 2009), as well as the link between KSS and regional innovation system and policy (e.g. Roper et al., 2010; Tödtling et al., 2011). With the exception of studies by Fu et al., (2015) and Keupp and

Gassmann (2009), there are limited insights into the association between KSS and innovation barriers, and scarce research across HI and MI countries using country-level innovation data. This study aims to identify and compare different KSS and innovation barriers across manufacturing firms by using the UNESCO Institute of Statistic (UIS) global innovation data, which was launched in 2013.

The association between firms' openness towards external knowledge (i.e. external search breadth and depth) and innovation constraints has been investigated using Swiss innovation data (Keupp and Gassmann, 2009), Chinese innovation data (Fu et al., 2015), and an open innovation practice survey in China (Savitskaya et al., 2010). However, these studies focused on firm-level analysis. In relation to innovation barrier studies, Hueske and Guenther (2015) argue that there is little evidence from developing countries such as South American and African countries. Therefore, future studies should address the innovation barrier differences between developing, newly industrialised, and developed countries (Hueske and Guenther, 2015). Using the UIS global innovation data, this study attempts to fill this research gap by identifying and comparing KSS and innovation barriers across manufacturing firms in HI and MI countries and aims to provide insights on the following research question: *"What is the difference in the KSS performed, and innovation barriers faced, by manufacturing firms across HI and MI countries?"*

The findings are expected to contribute to the empirical evidence on the linkage between KSS and innovation barriers, since to date such evidence is relatively scarce. In doing so, this research delivers policy implications and recommendations on the design of future innovation policies and strategies that will be able to address and tackle factors related to KSS that prevent manufacturing firms across HI and MI countries from engaging in innovation activities.

The next sections of this study are organised as follows. In section 2.2, the conceptual foundation and hypotheses related to KSS and innovation barriers are presented. Section 2.3 explains the data and methods used in this study. Furthermore, Section 2.3 describes the data, variables and methods used to the proposed hypotheses. Section 2.4 reports the results, and details the extent to which the proposed hypotheses are confirmed. The final section (section 2.5) contains the discussion and conclusions.

2.2. Conceptual Foundation and Hypotheses Development

2.2.1. Knowledge sourcing strategy classification

Sources of knowledge for innovation come from inside (internal sources) and outside (external sources) firms' boundaries. Attempts have been made to classify various sources of knowledge use for innovation. The 3rd edition of the Oslo Manual (OECD and Eurostat, 2005) divides sources of knowledge into four categories, namely: (1) *internal sources within the enterprise* (e.g. R&D, production, marketing, distribution); (2) *market/commercial sources* (e.g. competitors, other enterprises in the industry, clients or customers, consultants/consultancy firms, suppliers of equipment, materials, components, software or services, and commercial laboratories); (3) *public sector sources* (e.g. universities and other higher

education institutions, government/public research institutes, private non-profit research institutes, and specialised public/semi-public innovation support services); and (4) *general information services* (e.g. patent disclosures, professional conferences, meetings, branch literature and journals, fairs and exhibitions, professional associations and trade unions, other local associations, informal contracts or networks, standard or standardisation agencies, and public regulations) (OECD and Eurostat, 2005).

Based on the CIS data on European firms, Srholec and Verspagen (2012) classified external sources of knowledge into three groups, namely (1) *a scientific based approach* that combines sources of information from universities and research institutes; (2) *a client and industry approach* that combines information from customers, competitors and other firms in the same group; and (3) *a supplier based approach* that mainly uses information from suppliers. Roper et al., (2008) divide knowledge sourcing into five different activities such as in-house R&D, forward linkages to customers, backwards links to either suppliers or external consultants, horizontal linkages to either competitors or through joint ventures, and linkages to universities and other public research centres. The following section discusses the determinants, advantages and disadvantages of each KSS i.e. internal, external, and integration.

2.2.1.1.Internal knowledge sourcing strategy (Internal KSS)

In this study, internal KSS is defined as internal R&D activities. Firms decide to employ internal KSS for innovation for several reasons. Having high level technological resource availability or R&D intensity provides firms with an advantage in regard to the vertical integration of R&D activities and therefore a diminished probability of the externalisation of R&D (Williamson, 1985). Firms' internal resources positively influence innovation performance, while knowledge created from external networks has a limited impact (e.g. Freel, 2003; Oerlemans et al., 1998). Performing internal R&D and other internal innovation activities is essential for firms to develop sufficient absorptive capacity i.e. firms' ability to recognise and adapt to externally acquired knowledge (Cohen and Levinthal, 1990). Knowledge inside firms may be transferred more often than external knowledge due to the ease of communication between insiders in terms of accessing that knowledge, such as through informal means such as phone calls and meetings (Darr et al., 1995).

Although internal KSS provides a crucial benefit in regard to developing firms' capabilities, such a strategy has several limitations. The quality, innovativeness, and scope of internally generated knowledge may be limited by a firm's existing knowledge base (Oxley and Sampson, 2004). Segarra-Ciprés et al., (2012, p. 203) argue that "competitive advantage in innovation is not based so much on an organisation's internal resources as on its capacity to detect valuable external knowledge and integrate it into its own innovation process". Chesbrough (2006) stresses the importance of external knowledge for firms' innovation through his open innovation paradigm and argues that internal R&D and internal knowledge alone are no longer the exclusive source of strategic assets.

2.2.1.2.External knowledge sourcing strategy (External KSS)

External knowledge sourcing means that a firm acquires knowledge from external sources and the result is integrated with existing knowledge to add strategic value (Lichtenthaler, 2011). Firms can tap into external sources of technology and knowledge through acquisitions, alliances, joint ventures, licensing, etc. (Chiesa et al., 2000). One of the main reasons why firms need to perform external KSS, is because "firms should concentrate internally on activities that are strategically important to them, and through which they are capable of generating sustainable competitive advantage" (Mudambi and Tallman, 2010, p. 1434). In addition, due to the drastic changes in technology, not all firms are able to develop everything in-house and they need to externally source technology from other organisations to obtain the demanded products and services (Chesbrough and Crowther, 2006). In relation to the resource-based view (RBV), external KSS is conducted when firms do not have the necessary resources to develop a specific set of technologies in-house or when they do not possess a particular experience or core activities (Mol, 2005).

Sourcing knowledge from external sources has gained a lot of attention, and it offers several benefits for firms. Drawing simultaneously from different external sources of knowledge is a key to successful innovation, enabling firms to keep up with the rapid technological and market developments (Laursen and Salter, 2006). As a consequence, important issues to support the success of the innovation process are building and managing linkages with other firms in order to acquire their knowledge and capabilities (Chesbrough, 2003; Powell et al., 1996) and firms' speed in integrating and adopting current and acquired external knowledge can influence their sustainable competitiveness (Henderson and Clark, 1990; Kogut and Zander, 1992; Powell et al., 1996). Whether external knowledge acquisition always results in a high level of innovation performance remains a debated and open issue (Grimpe and Kaiser, 2010). Disadvantages of external knowledge sourcing have also been highlighted by previous scholars, who have suggested not overestimating the use of external knowledge in firms' innovation process because innovation efforts are not only made by firms themselves but are also generated in-house (e.g. Nelson, 2000) and external knowledge can cause firms' core competence to be weakened (e.g. Coombs, 1996). Firms may face social, physical, and legal barriers that hamper knowledge transfer (Menon and Pfeffer, 2003). Furthermore, over-searching for external knowledge can impede firms' innovation performance (Laursen and Salter, 2006).

2.2.1.3.Integration knowledge sourcing strategy (Integration KSS)

When a firm is operating in a market that has a great diversity of technology, it will tend to externalise its R&D activities (Cesaroni, 2004). However, internal R&D activities need to be conducted when technological changes are unpredictable, and balancing between the two activities is vital in order to

maintain awareness of technology shifts and obtain greater flexibility by performing external KSS (Cruz-Cazares et al., 2013). Therefore, absorptive capacity and open innovation converge when a firm is successfully balancing its efforts in the two activities (Cruz-Cazares et al., 2013).

From an integrative perspective, scholars have argued that internal and external knowledge acquisition can be complementary activities in firms' innovation strategy (e.g. Battisti and Stoneman, 2010, 2013; Cassiman and Veugelers, 2006; Roper et al., 2008; Veugelers, 1997). Previous studies have revealed that achieving superior innovation performance can be achieved by performing internal and external R&D compared to the case of performing either internal or external R&D (e.g. Berchicci, 2013; Grimpe and Kaiser, 2010). Firms may achieve better innovation performance by integrating both internal capabilities and external knowledge (e.g. Caloghirou et al., 2004; Shan Su et al., 2009). Furthermore, internal capabilities provide firms with a foundation to identify and explore external opportunities from the firms' partnership that will lead to furthering firms' internal capabilities exploitation and, based on the complementary and interactive relationships between internal and external knowledge, will influence firms' innovativeness (Shan Su et al., 2009). However, a challenge that remains for firms that employ integration KSS is balancing both internal and external knowledge sourcing activities to capture the benefit from external sources (Berchicci, 2013).

2.2.2. Knowledge sourcing strategy: A cross-country perspective

In this section, key issues related to hypotheses development, i.e. manufacturing firms in HI and MI countries source different types and levels of necessary knowledge use for innovation, is discussed. The discussion includes any relevant backgrounds that explain why the firms in both the country groups usually source necessary knowledge for innovation differently. Previous empirical findings on KSS across HI and MI countries are also discussed.

2.2.2.1. Knowledge sourcing strategy in HI countries

It is argued that KSS in the context of HI or developed countries has shifted from an internal, closed or traditional approach to a more open approach. From the traditional perspective of producing knowledge, internal R&D is seen as the main source of knowledge generation (e.g. Rothwell, 1992) and therefore firms need to protect their ideas using intellectual property rights (IPR) (Battisti et al., 2014). In this sense, firms may gain strong incentives if their innovation activities are dominated by secretive and self-contained internal R&D. A large body of empirical studies supports this traditional perspective of innovation activities pursued according to a closed innovation model. For example, the studies conducted by Freel (2003) in the UK and Oerlemans et al. (1998) in the Netherlands show that innovation performance is mainly influenced by firms' internal resources and that knowledge from external networks has a limited impact. A recent study shows that innovation leaders, which consist of advanced countries in the EU, tend to rely on an internal

source of knowledge, i.e. performing internal R&D activities, to produce radically innovative products, instead of performing an open innovation strategy (e.g. Battisti et al., 2014).

Other perspectives, such as the evolutionary approach (Nelson and Winter, 1982) and a new emerging modern innovation model i.e. open innovation (Chesbrough, 2003), put forward a different argument to the traditional approach to innovation activities. The roles of internal capabilities and external networks have only been discussed in broad terms in the evolutionary approach (Malerba and Torrisi, 1992). Other scholars have emphasised the role of internal capability (Cohen and Levinthal, 1989, 1990), opening linkages between firms and external organisations (Chesbrough, 2003), and moving up from 'research and develop' to 'connect and develop' (Houston and Sakkab, 2006). A wide range of factors have been identified that drive the shift from traditional to open innovation systems. Constraints related to internal factors, such as information-, capability-, and risk-related impediments may push firms to open up the innovation process and therefore increase the breadth and depth of open innovation (e.g. Keupp and Gassmann, 2009). Pull factors related to firms' external environment also motivate firms to be more open, for example environmental change and pressure; the availability of skilled workers, knowledge, or venture capital; the intensity of competition (Chesbrough, 2003); technology intensity and fusion (Gassmann, 2006), and partner advantages (Hagedoorn, 2002). Previous empirical studies show positive influence of external knowledge on innovation performance and largely focus on the dimension of *breadth* (diversity of search activities) and *depth* (intensity of search activities) (e.g. Katila and Ahuja, 2002; Laursen and Salter, 2006).

Complementarity or substitution choice in terms of the use of internal and external knowledge and its influence on innovation performance have also been studied previously and the findings are inconclusive. For example, Laursen and Salter (2006) found that the relationship between internal and external knowledge in UK manufacturing firms is substitution, while the majority of other studies reveal that the relationship is complementary (e.g. Berchicci, 2013; Cassiman and Veugelers, 2006; Schmiedeberg, 2008). Despite the inconclusiveness of studies on the usage of internal and external sources of knowledge for innovation in the context of HI countries, this study proposes that firms in HI countries make more use of internal R&D than their counterparts in MI countries, and the three following arguments support that premise. *First*, the level of R&D differentiates innovation activities between firms in developed and developing economies. As argued by Hobday (2005, 136), "the empirical evidence on latecomer innovation contrasts markedly with traditional 'Western' models of innovation and places advanced R&D at the centre of innovation". *Second*, internal R&D activities in HI countries are dominated by the business sector, while in MI countries, governments are the main funders of R&D activities (Dahlman, 2010). Accordingly, innovation activities in HI countries are dominated by firms' internal R&D activities, while in MI countries firms rely on public or government R&D activities. *Third*, globally, the top performers and spenders in terms of R&D are dominated by firms in developed countries (Dahlman, 2010).

2.2.2.2. Knowledge sourcing strategies in MI countries

The following are rationales for why it is important for the majority of firms in MI countries to source knowledge from external environments to complement their internal stock of knowledge. *First*, substantial obstacles are faced by the majority of firms in MI countries. The main characteristic that differentiates the majority firms in MI from those in HI countries is the lack of a mature and effective innovation ecosystem, very low R&D investment and activities, a weak open innovation network and intellectual property rights (Becheikh, 2013). For developing countries, inadequate human capital and poor infrastructure are substantial obstacles and therefore performing internal innovation activities is a huge constraint for many firms. As a result, instead of performing inventions that are new to the market, most firms attempt to reach the technological frontier (Hou and Mohnen, 2013). *Second*, the industrial transformation has influenced the increase in MI countries' reliance on international technology sourcing and knowledge linkages (Ernst, 2002). Therefore, knowledge and technologies used for innovation are usually sourced from external sources, such as international sources (Kesidou and Szirmai, 2008). *Third*, an external knowledge sourcing strategy has an important role in the learning process (Freeman, 1989) along with narrowing the gap between domestic and international technological capabilities by upgrading the existing technology to meet international standards (Aggarwal, 2000). Therefore, even the most innovative firms in MI countries are committed to getting involved in external knowledge sourcing activities (Freeman, 1989).

However, there is no guarantee that firms will achieve successful learning if they source just external knowledge (Matusik, 2000). Therefore firms in MI countries "need to blend diverse international and domestic sources of knowledge to compensate for initially weak national production and innovation systems" (Ernst, 2002, p. 498). Failure to learn is quite common in MI countries because firms that source technology from external sources lack the appropriate internal technological capability (Cooper, 1989) and such capability is crucial for firms to codify the tacit components of the technology (Lall, 1980). Improving "absorptive capacity" is also crucial for firms in MI countries because such capacity has important dual roles in building up firms' own technology (i.e. by performing internal R&D) and absorbing external know-how (Cohen and Levinthal, 1989, 1990).

Previous studies have been conducted on firms' knowledge sourcing activities in MI countries. The studies show that knowledge sourcing activities mainly focus on the interdependent relation between internal R&D and external knowledge. In the case of Indian firms acquisitioning technology, a complementary relationship between in-house R&D and imported technology has been found (Deolalikar and Evenson, 1989). A robust complementary relationship between firms' technology effort and technology buying has also been found in Brazilian industry (Braga and Willmore, 1991). A case study of the innovation strategies used by five leading firms from different sectors (Pharmaceuticals, Automotive, and Retail) in India, conducted by Krishnan and Jha (2011), reveals that all of the firms use a combination of

internal and external sources of knowledge to develop their capabilities. Instead of performing internal R&D, technology firms source heavily from external sources through acquisition and alliances to complement their internal capabilities (Krishnan and Jha, 2011). Li (2011) investigated the impact of three types of knowledge (i.e. internally developed knowledge (in-house R&D), knowledge acquired externally from foreign countries, and knowledge acquired from domestic sources such as universities, research centres, or other domestic firms) on the innovation capability of Chinese state-owned enterprises (SOEs) in high-tech sectors. Hence, the following hypotheses are proposed:

H1a Manufacturing firms in HI countries make more use of internal R&D than firms in MI countries.

H1b Manufacturing firms in MI countries make more use of external knowledge sources than firms in HI countries.

2.2.3. Innovation barrier classification

Sandberg and Stenroos (2014, p.1294) defined an innovation barrier as "an issue that either prevents or hampers innovative activities in the firm". The ability to identify barriers means "the firm's awareness of the difficulties involved as a result of engagement in innovation activities" (D'Este et al., 2012, p.482). Despite the fact that the research interest in innovation barriers has been growing, such a research interest is much smaller and less organised than the innovation driver approach (Hölzl and Janger, 2011). This section intends to identify a wide range of innovation barriers from previous studies. Previous studies have classified innovation barriers in several ways, for instance, internal (endogenous) versus external (exogenous) barriers (e.g. Piatier, 1984); revealed versus deterring barriers (e.g. D'Este et al., 2012); the environment, organisation, group, and individual (EOGI) model (Hueske and Guenther, 2015); and the five factors related to innovation barriers (i.e. cost, knowledge, market, institutional, and other reasons) that are classified in the 3rd edition of the Oslo Manual (OECD and Eurostat, 2005).

Internal barriers can be subdivided into a lack of internal funds, technical expertise or management time, culture and systems (e.g. Rush and Bessant, 1992), firms' resources and capability (e.g. Hewitt-Dundas, 2006), and human nature related e.g. employee resistance to innovation (e.g. Zwick, 2002). Internal barriers have been examined from a resource-based view of the firm (RBV) (Hadjimanolis, 1999; Hewitt-Dundas, 2006). In relation to KSS, firms' resources and capability may have links with their ability to integrate specialist knowledge for innovation that can be sourced from internal and external firms (Hewitt-Dundas, 2006). External barriers can be subdivided into supply (e.g. constraints in obtaining technological information, raw materials, and finance), demand (e.g. constraints related to customers, the perception of innovation risks, and domestic and international market issues) and environment (e.g. government regulations and policies) (Hadjimanolis, 1999).

As the UIS global innovation data that is used in this study is mainly based on the 3rd Oslo Manual (the guidelines for collecting and interpreting innovation data), the discussion on internal and external

innovation barriers will be linked to the five factors related to barriers classified by the Oslo Manual. Therefore, innovation barriers, as presented in Table 2.2, can be grouped into: (1) internal barriers related to *cost* (e.g. a lack of internal funding and the high cost of innovation), *knowledge* (e.g. a lack of information on markets and technology, and a lack of qualified personnel), and *other reasons* (e.g. no need to innovate due to prior innovation), (2) external barriers related to *cost* (e.g. a lack of external funding), *knowledge* (e.g. difficulty in finding cooperation partners), *market* (e.g. market dominated by established firms, and uncertain demand for innovative products), and *other reasons* (e.g. no need to innovate due to lack of demand).

2.2.4. Innovation barriers: A cross-country comparison

This section compares the innovation barriers that hinder the innovation activities performed by manufacturing firms in HI and MI countries. A wide range of factors that hamper, delay or block innovation activities, which are well-known as barriers, have been studied for more than 30 years (Hueske and Guenther, 2015). However cross-country studies on innovation barriers have mostly been conducted in an advanced country context, such as European countries (e.g. Buligescu et al., 2012; Canepa and Stoneman, 2002; Efthyvoulou and Vahter, 2012; Eggers et al., 2014; Ferrando and Ruggieri, 2015; Hölzl and Janger, 2013, 2014; Mohnen et al., 2008) and mainly in a single country context (Hölzl and Janger, 2014). By contrast, only a few developing country studies on innovation barriers can be found (e.g. Doruk and Soylemezoglu, 2014).

The following are examples of various cross-country innovation barrier studies that have been conducted. A pioneering study on innovation barriers covering eight European countries was conducted by Piatier (1984) for the Commission of European Communities. Some major barriers related to the education system and skilled labour, the impact of venture capital and banks on funding innovation, and the effect of norms, legislation, and public bureaucracy were identified in the study. The impact of financial constraints on innovation activities, innovation performance and productivity across European countries has been studied by previous scholars, such as Canepa and Stoneman (2002), Efthyvoulou and Vahter (2012), and Ferrando and Ruggieri (2015). Mohnen and Röller (2005) used the first wave of the Community Innovation Survey dataset to study discrete complementarities of innovation policy on innovation barriers across European countries. Social attitudes and consumers' resistance towards innovation across European countries was studied by Buligescu et al., (2012). Innovation barriers and their impact on the high growth across firms in European countries was studied by Hölzl and Janger (2013). Hölzl and Junger (2014) investigated external innovation barriers across 18 European countries with diverse levels of economic and technological development. In the context of developing countries, Doruk and Soylemezoglu (2014) investigated innovation barriers that hamper start-ups across 61 developing countries by employing World

Bank data. However, there is limited insight on the difference in the innovation barriers faced by HI and MI countries based on cross-country studies.

It is argued that firms in HI and MI countries naturally face different innovation barriers due to the two country groups having differences of, for instance, technological capabilities (e.g. Archibugi and Coco, 2004), as well as innovation models and catch up dimension (e.g. Hobday, 2005). Acemoglu et al. (2006) reveal that the closer firms are to the technological frontiers the more likely they are to perform innovation-based competitive advantage based on research and their own knowledge creation. However, own innovation-based strategies need different inputs, such as finance, skills, and technological knowledge, compared to the absorption of existing technologies (Hölzl and Janger, 2014). In this regard, firms operating in developing countries often face obstacles to innovation such as a lack of financial capital (e.g. Shiang and Nagaraj, 2011; Xie et al., 2010), skilled labour (e.g. Demirbas et al., 2011; Shiang and Nagaraj, 2011), and technical expertise and a low level of innovativeness (e.g. Lall, 1983; Levy, 1993). Furthermore, "medium- and low-income countries allocate significantly fewer resources to the creation of a knowledge base than do high-income countries" (Meriküll, et al., 2011, p. 59). Therefore, firms in MI countries may face greater constraints on resources and capabilities than their counterparts in HI countries, which are dominated by developed economies and technological frontiers.

In an MI focused study, Xie et al. (2010) found that many Chinese SMEs lack technical experts, financial capital and technical information, and incur a low rate of return, and a high cost and risk of innovation. The internal barriers that hamper innovation activities that are perceived to be important by Malaysian manufacturing firms consist of high costs, a lack of skilled labour and a lack of finance (Shiang and Nagaraj, 2011). The intensity of R&D/employees, the education of the entrepreneurs, and a lack of qualified personnel are internal factors hampering the innovation activities of Turkish firms (Demirbas et al., 2011).

In relation to external innovation barriers, based on the case of Chinese firms, Savitskaya et al. (2010) found that the underdevelopment of technology markets in China affects external technology acquisition and is one of the most important barriers perceived by Chinese firms. In their study of barriers related to institutions hampering innovation activities of Chinese SMEs, Zhu et al found that the top five barriers are competition fairness, access to financing, laws and regulations, the tax burden, and public support systems (Zhu et al., 2012). Barriers related to external factors that hamper the innovation activities of Turkish firms consist of the high cost of innovation and a lack of appropriate sources of finance (Demirbas et al., 2011). Due to the lack of adequate resources and capacities as well as the increase in internal R&D costs and risks, many Chinese firms are not able to perform innovation activities on their own and as a result most of them have decided to source external knowledge and resources (Fu et al., 2015). Therefore, the following hypothesis is proposed:

H2 Manufacturing firms in MI countries face higher levels of innovation barriers than those in HI countries.

2.3. Data and Methods

This section discusses the empirical strategy used to test the hypotheses. First, the data used in this study are described. Following this, the main variables of this study and their measures are presented. Lastly, the methods applied to investigate the hypotheses are briefly discussed.

2.3.1. Data

All the aggregated micro-data on sources of innovation and innovation barriers used in this study are drawn from the first global innovation data of the UNESCO Institute for Statistics (UIS). The majority of the innovation data in the UIS is described in the 3rd edition of the Oslo Manual (OECD, 2005). The UIS developed a database of cross-nationally comparable statistics on innovation by collecting pilot data on innovation in 2011. Then, based on the pilot study's results, global data collection covering all countries with innovation surveys was launched in August 2013. However, the global data only covers innovation data on manufacturing firms. This study uses data representing the innovation indicators of manufacturing firms across 53 high- and middle-income countries from the 2010 datasets. Where data are not available or accessible, the data from the closest year have been used.

Appendix 2.4 presents the list of countries used in this study. The countries are listed based on their gross national income (GNI) per capita, in order (rank) from the highest to the lowest; the first 26 countries are classified as high-income countries, while the rest are classified as MI countries, which consist of upper- and lower-middle income countries. The countries' classification in this study is based on the World Bank country classification, which uses GNI per capita to group the countries. The country classification is divided into four groups (1) *high-income group (HI)* - countries that have a GNI per capita of USD 12,616 or more, (2) *upper-middle income group (UMI)* - countries that have a GNI per capita of USD 4,086 to 12,615, (3) *lower-middle income group (LMI)* - countries that have a GNI per capita of USD 1,036 to 4,085, and (4) *lower income group (LI)* - countries that have a GNI per capita of USD 1,035 or less.

2.3.2. Methods

2.3.2.1. Descriptive statistics

In this study, descriptive statistics are used to examine the general patterns in the use of various sources of knowledge and innovation barriers among manufacturing firms in HI and MI countries.

2.3.2.2. The Mann-Whitney test for two independent samples

The Mann-Whitney test is a nonparametric test used to assess whether two independent samples have been drawn from the same population. It is assumed that the variables being tested are at least at the ordinal level. The test is often used when there is a violation of the normality assumption or when the data level is not appropriate for the t-test. In this study prior to using the Mann-Whitney test, the Kolgomorov-Smirnov test was used to assess the distribution equality of the sources of knowledge and innovation barriers variables.

2.3.2.3.Scatter plot

A scatter plot is used to display countries' position against diverse types of sources of knowledge and innovation barriers.

2.3.3. Variables and measures

2.3.3.1. Sources of knowledge

Knowledge use for innovation consists of internal and external sources of knowledge as presented in Table 2.1.

Table 2.1 Sources of knowledge

Sources of knowledge	**Description**
IN_RD	Proportion of manufacturing firms that engaged in internal R&D.
SUPPLIERS	Proportion of manufacturing firms for which *suppliers of equipment, materials, components or software* were a very important source of information.
CUSTOMERS	Proportion of manufacturing firms for which *clients/customers* were a very important source of information.
COMPETITORS	Proportion of manufacturing firms for which *competitors/other enterprises* in their sector were a very important source of information.
CONSULTANTS	Proportion of manufacturing firms for which *consultants, commercial laboratories or private R&D institutes* were a very important source of information.
UNIVERSITIES	Proportion of manufacturing firms for which *universities/other higher education institutions* were a very important source of information
RES_INSTITUTES	Proportion of manufacturing firms for which *the government/public research institutes* were a very important source of information.
EVENTS	Proportion of manufacturing firms for which *conferences, trade fairs, exhibitions* were a very important source of information.

PUBLICATIONS	Proportion of manufacturing firms for which *scientific journals and trade/technical publications* were a very important source of information.
ASSOCIATIONS	Proportion of manufacturing firms for which *professional and industry associations* were a very important source of information.

Source: the UIS global innovation data

2.3.3.2. Innovation barriers

The innovation barriers in this study consist of eleven factors that hamper innovation activities. They are derived from the UIS global innovation data, as presented in Table 2.2. Six barriers including INFUND, HIGH_COST, PERSONNEL, TECH_INFO, MARKET_INFO, and PRIOR_INNOV are internal barriers, and are related to firms' resources and capabilities; while the rest, e.g. NO_DEMAND, COOPERATION, MKT_DOMINATION and UNCERTAIN_DEMAND are classified as external barriers and relate to actors outside of firms such as competitors, customers, and suppliers as well as external conditions.

Table 2.2 Innovation barriers

INNOVATION BARRIERS	DESCRIPTION
INFUND	Lack of funds within the enterprise or enterprise group was a very important hampering factor.
EXTFUND	Lack of financing from sources outside the enterprise was a very important hampering factor.
HIGH_COST	The high costs of innovation were a very important hampering factor.
PERSONNEL	The lack of qualified personnel was a very important hampering factor.
TECH_INFO	The lack of information on technology was a very important hampering factor.
MARKET_INFO	The lack of information on markets was a very important hampering factor.
COOPERATION	Finding cooperation partners for innovation was a very important hampering factor.
MKT_DOMINATION	The market being dominated by established enterprises was a very important hampering factor.
UNCERTAIN_DEMAND	The uncertain demand for innovative goods or services was a very important hampering factor.
PRIOR_INNOV	No need to innovate due to prior innovations was a very important hampering factor.
NO_DEMAND	No need to innovate due to no demand for innovations was a very important hampering factor.

Source: the UIS global innovation data

2.4. Results

2.4.1. Descriptive statistics and median test

2.4.1.1. Sources of knowledge comparison

Table 2.3 shows the descriptive statistics and the Mann-Whitney test outputs on the knowledge sources variables. Each proportion other than IN_RD and GERD represents the percentage of manufacturing firms for which each external source of knowledge is a highly important source. IN_RD indicates the percentage of manufacturing firms in HI and MI countries that perform internal R&D and GERD represents the government (public) investment in R&D. For all country group, knowledge that is sourced from internal R&D accounts for the highest proportion compared to other sources of knowledge. In the same group, it is also found that knowledge from external sources, for example, MARKET (e.g. customers, suppliers and competitors) and EVENTS (e.g. conferences, trade fairs and exhibitions, in which customers, suppliers, and competitors may be involved) stands out as being more important than other sources of knowledge, its proportion ranges from around 16% to 37%. In contrast, three sources of knowledge, from UNIVERSITIES, RES_INSTITUTES and ASSOCIATIONS, account for the lowest proportion, ranging from around 3% to 10%.

Prior to running the Mann Whitney-U (MWU) test, a Kolgomorov-Smirnov (K-S) test, to assess the equality of the distribution, was performed. The K-S test showed that some dependent variables violated the required normal distribution (see the appendix 2.1); hence t-test procedures were less suitable and the non-parametric MWU test on significant median difference was used.

Table 2.3 Descriptive statistics & the Mann Whitney-U (MWU) test: Sources of knowledge for innovation

SOURCES OF KNOWLEDGE	ALL	HI	MI	Mann-Whitney Z(U)
IN_RD[1]	48.90	55.98	41.55	2.71***
GERD[2]	1.35	1.96	0.69	4.46***
SUPPLIERS	28.59	28.01	29.19	-.64
CUSTOMERS	37.19	36.86	37.50	-.30
COMPETITORS	17.79	16.63	18.87	-.998
CONSULTANTS	10.83	10.54	11.11	-.49
UNIVERSITY	6.63	5.14	8.12	-.38
RES_INSTITUTE	6.35	3.79	9.03	2.05**
EVENTS	17.98	16.39	19.70	2.10**
PUBLICATION	12.51	10.56	14.64	1.95*
ASSOCIATION	8.80	7.41	10.45	-1.54

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.01; HI: high-income; MI: middle-income; [1]Proportion of manufacturing firms that perform internal R&D; [2] Countries' (public) R&D expenditure as % of GDP that is derived from World Development Indicator 2010, the World Bank

The MWU test shows that HI economies have a significantly greater internal R&D and GERD proportion than MI countries. This is in line with previous studies (e.g. Becheikh et al., 2006; Fagerberg et al., 2010)

and reveals that firms in advanced countries usually perform intramural R&D and collaborative R&D activities to create the knowledge necessary for innovation. The lower level of internal R&D activities in MI countries also supports a recent study conducted by Cirera et al., (2015), which states that the majority of firms in MI countries do not invest in R&D, even if they innovate. However, the MI countries group has a higher level of external knowledge, such as RES_INSTITUTE, EVENTS, and PUBLICATION, than the HI countries. This may indicate that manufacturing firms in MI countries use external knowledge to complement their lower level of internal R&D activities (see table 2.3). This in line with previous studies (e.g. Ernst, 2002; Kesidou and Szirmai, 2008), which state that the knowledge and technologies necessary for innovation in developing countries are rarely developed by the firms and often brought from external sources. Based on this, it may be summarised that manufacturing firms in HI countries make more use of internal R&D than firms in MI countries; hence hypothesis H1a can be accepted. H1b, which posits that manufacturing firms in MI countries make more use of external knowledge sources than firms in HI countries can also be accepted. The reasons for scanning and sourcing information and knowledge from research institutes, events, and scientific publication may vary. As argued by Grimpe and Sofka (2010, p. 1491), "universities and other public research institutes are primary producers of fundamentally new knowledge and technologies". Other scholars (e.g. Shrolec and Vesrpagen, 2012) have stated that universities and research institutes are external sources of knowledge that provide 'science-based' knowledge. Firms may subscribe to scientific and business publications, which are used in a regular manner to seek new ideas for innovation (Caloghirou et al., 2004), while conferences, trade fairs, and exhibitions (EVENTS) can be a good opportunity to update information related to the equipment and technology used in the innovation process as well as to network with various suppliers, buyers and business partners.

In this section, scatter plots are presented to display countries' position against various sources of knowledge. Figure 2.1 presents scatter plots of IN_RD performed by manufacturing firms across HI and MI countries. The vertical line represents the proportion of manufacturing firms that perform IN_RD. The plot clearly shows that most manufacturing firms in HI countries source knowledge from internal sources by performing IN_RD (i.e. its range from 30% to 90%) greater than their counterparts in MI countries. Of the HI countries, the highest proportion of firms that source knowledge from in-house R&D are from Korea and Finland (i.e. more than 80%); by contrast, Australia has the lowest proportion of firms (i.e. below 30%). In the case of MI countries, there are two country groups that have different proportion ranges of internal R&D activities. The first group consists of the majority of countries that source knowledge from internal R&D; where the percentage of firms relying on internal R&D ranges from 30% to 80%, Indonesia is one of the countries in this group. The second group consists of six countries (i.e. Bulgaria, Panama, Russia, Brazil, Ukraine, and Colombia) with a proportion lower than 30%. Hence, in terms of IN_RD, the spread among HI and MI countries is similar but the average level is lower in the MI countries.

Figure 2.1. Scatter plots: Source of knowledge (Internal R&D)

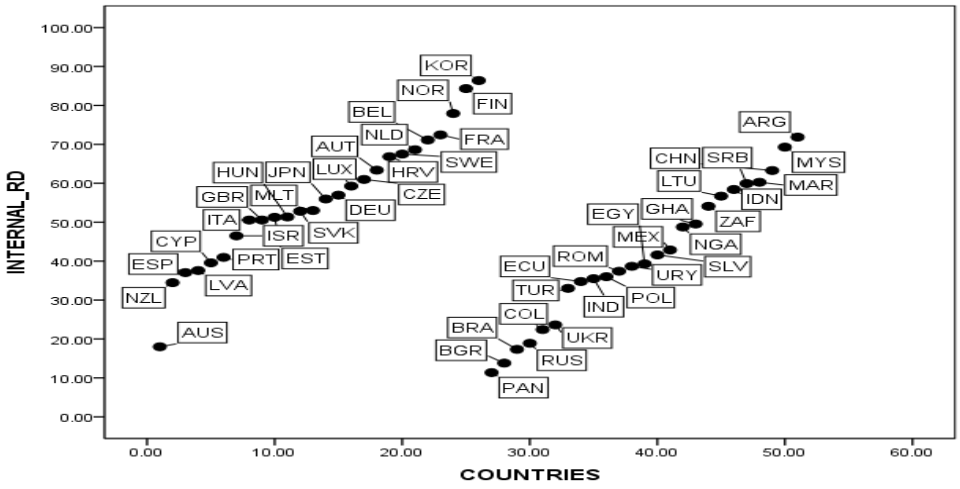


Figure 2.2 displays scatter plots comparison of RES_INSTITUTE as an important source of knowledge between the HI and MI countries. The vertical line represents the proportion of manufacturing firms that source knowledge from RES_INSTITUTE. Argentina has the highest proportion of manufacturing firms that source knowledge from RES_INSTITUTES. Based on this source of knowledge, the HI and MI countries can be clustered into groups. The first group consists of the majority of HI countries, where the proportion of manufacturing firms that source knowledge from RES_INSTITUTES is lower than 10%. The second group consists of Norway, which has a wide network of research institutes (e.g. SINTEF) and New Zealand, where the proportion of manufacturing firms that source knowledge from RES_INSTITUTES is greater than 10%. Meanwhile the MI countries group can be split into four different groups. The first group consists of countries where the lowest proportion of manufacturing firms source from RES_INSTITUTES, i.e. lower than 10%. In the second group (i.e. India, Morocco, and Malaysia) the proportion of firms that source from RES_INSTITUTES ranges from 10% to 20%. The proportion of firms in the third group of countries (i.e. Mexico, China, and Cuba) that source knowledge from RES_INSTITUTES range from 20% to 30%. The last group consists of Argentina, which is a clear outlier i.e. the proportion of firms that source knowledge from RES_INSTITUTES for innovation account for more than 40%.

Figure 2.2 Scatter plots: Source of knowledge (RES_INSTITUTES)

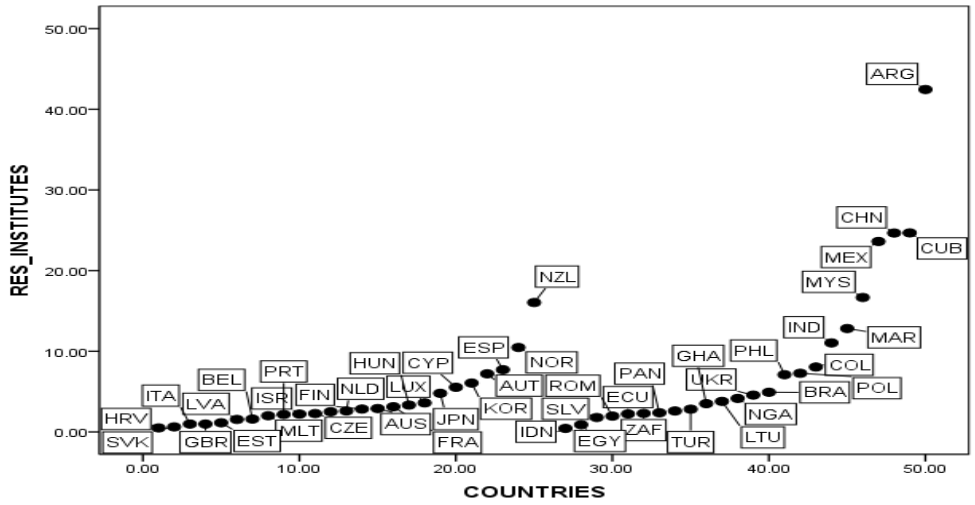


Figure 2.3 plots HI and MI countries against EVENTS as an important source of knowledge. The proportion of manufacturing firms in the majority of HI countries source knowledge from EVENTS is account lower than 20%. By contrast, firms in few HI countries such as Luxembourg, New Zealand, and Cyprus source knowledge from EVENTS are a greater level than 20%, and those small and open economies are outliers. In the case of MI countries, nearly 50% of firms source knowledge from EVENTS at a lower rate than 20%. Firms in Morocco and Colombia source the highest proportion from EVENTS (i.e. nearly 45%) and firms in the rest of the MI countries have proportion range from 20% to 40%. In other words, by excluding the three outliers in HI countries (Luxembourg, New Zealand, and Cyprus), the difference of firms' proportion that source knowledge from EVENTS between HI and MI countries would be even larger.

Figure 2.3 Scatter plots: Source of knowledge (EVENTS)

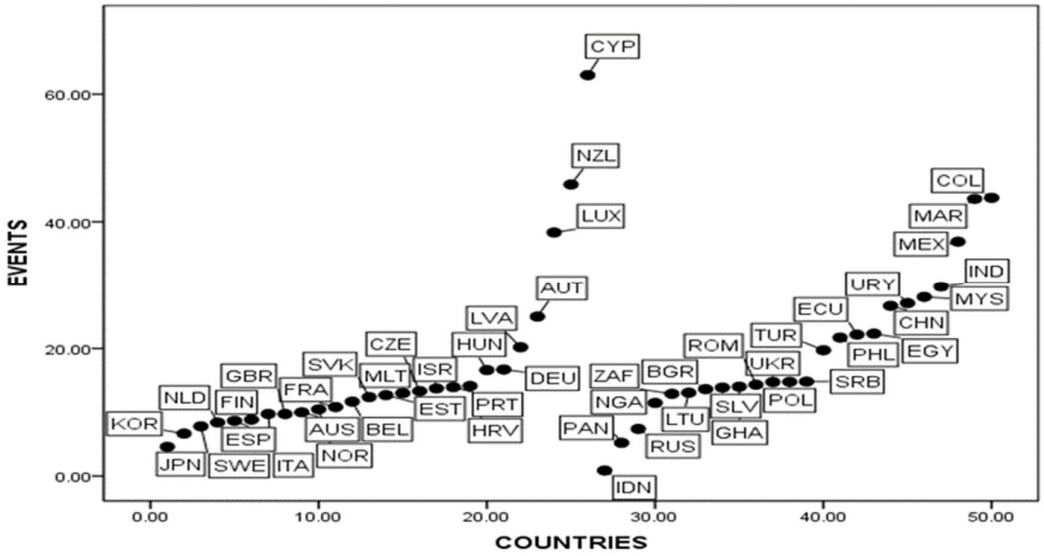


Figure 2.4 plots how manufacturing firms in HI and MI countries source knowledge from PUBLICATIONS. The firms in the majority of HI and MI countries source knowledge from

PUBLICATIONS at levels lower than 20%. Interestingly, firms in four countries from each country group source knowledge from PUBLICATIONS at a level greater than 20%, with Austria, Luxembourg, Cyprus, and New Zealand, from the HI group and Malaysia, Morocco, Ecuador, and Colombia, from the MI group.

Figure 2.4 Scatter plots: Source of knowledge (PUBLICATIONS)

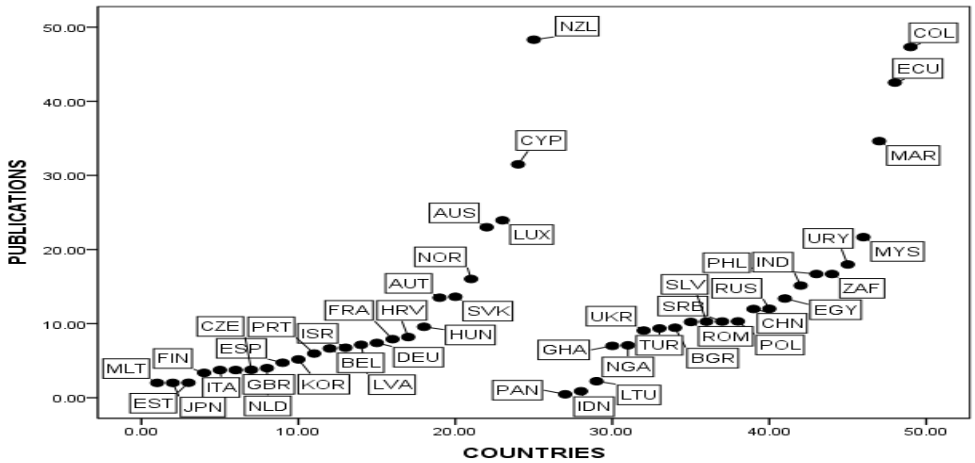


Figure 2.5 displays the comparison of public R&D investment (GERD) across the HI and MI countries. Nearly 50% of HI countries spend investment on GERD greater than 2%; which is consistent with the R&D investment policies above the 3% of GDP threshold of OECD countries. In contrast, all MI countries spend GERD lower than 2%. Korea, Finland and Israel lead the way in terms of GERD spending, where China spends the highest proportion of GERD (i.e. nearly 2%) among MI countries.

Figure 2.5 Scatter plots: GERD

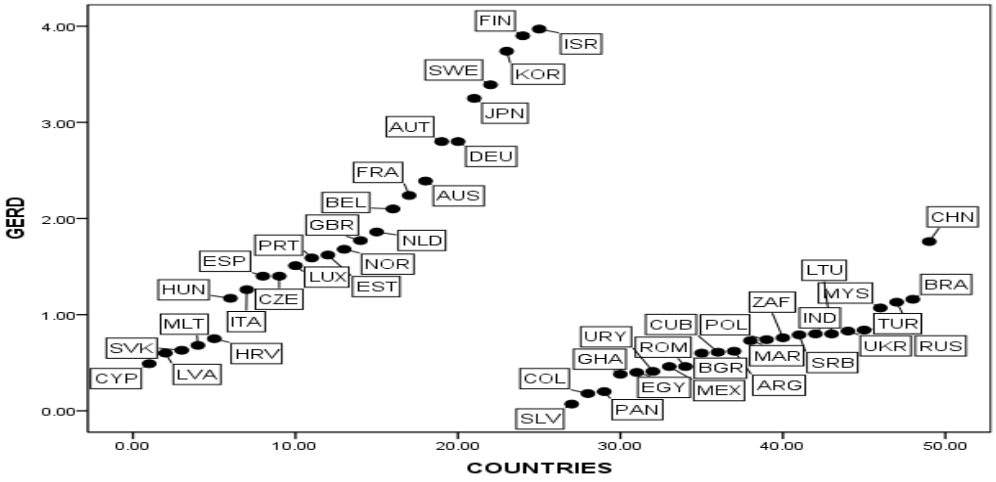
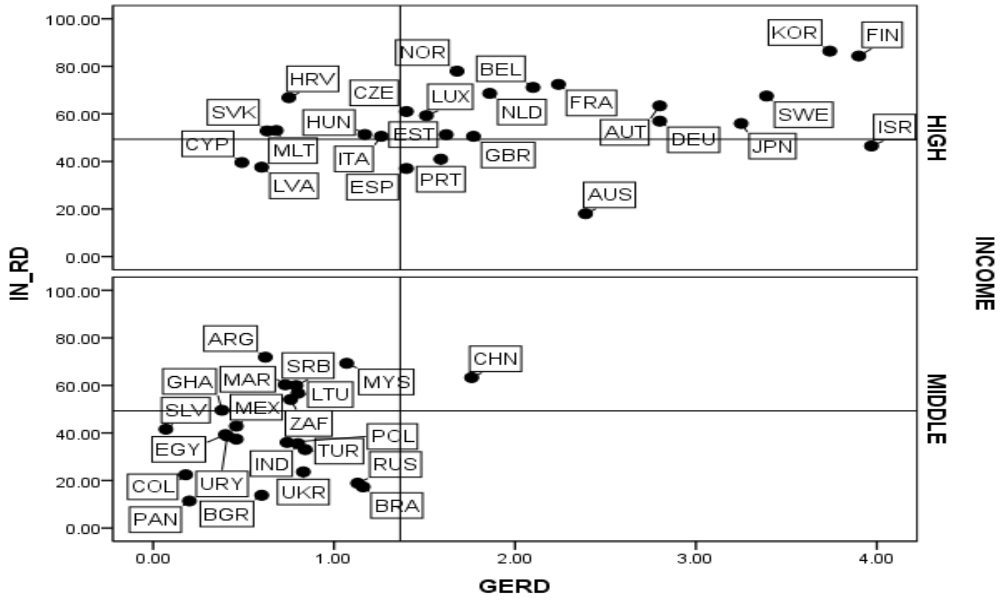


Figure 2.6 plots IN_RD against GERD across HI and MI countries. The horizontal line represents the mean of GERD, while the vertical line represents IN_RD. Countries in the top right-corner have a higher level of both IN_RD and GERD than other countries and mostly dominated by European countries. Korea and Finland are top performers of IN_RD activities and top spenders of public R&D investment (GERD) within HI countries; while China in MI countries group. This finding support previous studies (e.g. Acemoglu et al., 2006) stating that firms close to technological frontiers are more likely to perform innovation-based

competitive advantage that is based on research and own creation of knowledge. By contrast, countries such as Panama and Bulgaria are the least performers of IN_RD and the least spenders of GERD.

In the case of China, the country can be categorised as the catching up country because the country spends high proportion of both internal R&D and GERD as well as sourcing knowledge highly from scientific knowledge provider such as RES_INSTITUTES (see figure 2.2). This may indicates that China attempts to narrow the gap from the technological frontiers as argued by Savitskaya et al., (2010) that China has been moving its IPR regime closer to the same condition in many developed countries. The country also has transformed from manufacturing-based to knowledge-based production (Savitskaya et al., 2010) and shifted beyond acquiring global knowledge through copying, reverse engineering, foreign direct investment, and technological licensing to invest in innovation on its own (Dahlman, 2010). These indicators are in line with Hölzl and Janger (2014) that suggest own innovation-based strategies needs different necessary inputs such as finance, skills, technological knowledge than absorption of existing technologies.

Figure 2.6 Scatter plots: IN_RD VS GERD



Figures 2.7, 2.8 and 2.9 plot IN_RD against each external knowledge from RES_INSTITUTES, EVENTS, and PUBLICATIONS respectively. Each figure is divided into four groups of countries. Group 1 consists of countries in which the proportion of their firms highly source knowledge from IN_RD but source lower level from any of the three external sources of knowledge. Countries that their firms' proportion highly source knowledge from both IN_RD and any of the three external sources of knowledge are clustered in group 2. Group 3 consists of countries that their firms' proportion highly use knowledge from any of the three external sources of knowledge and lower firms' proportion source knowledge from IN_RD. Countries in which their firms source low-level knowledge from both IN_RD and any three external sources of knowledge are clustered in group 4.

Figure 2.7 plots IN_RD against RES_INSTITUTES variables. Within the HI countries, the majority of countries are located in the top left corner (group 1), above the average of IN_RD, fewer countries are in the group 2, and only a few countries are separated in group 3 and 4. In the group 2, the firms in Norway tend to source knowledge highly from both IN_RD and RES_INSTITUTES. New Zealander firms are highly source knowledge from RES_INSTITUTES but tend to source lower level of knowledge from IN_RD. Australian firms use a low level of knowledge from both IN_RD and RES_INSTITUTES. By contrast, few the MI countries are located in the top left corner (group 1), including Indonesia, more countries are in the group 4, and the rest of the countries are separated proportionately in group 2 and 3. The Chinese and Argentinean firms highly source knowledge from both IN_RD and RES_INSTITUTES, while Mexican firms tend to use knowledge from RES_INSTITUTES for innovation.

Figure 2.7 Scatter plot: IN_RD VS RES_INSTITUTES

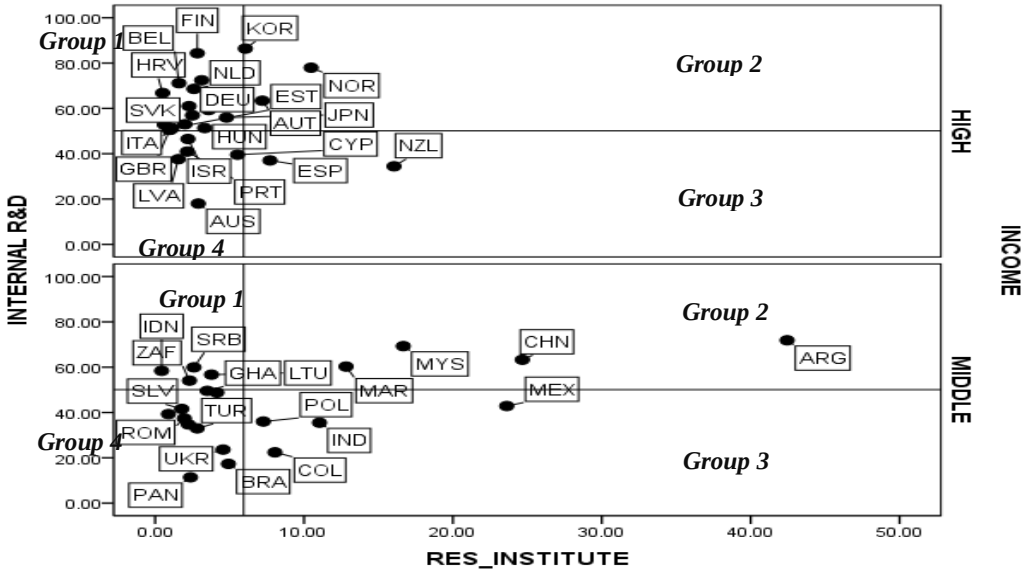


Figure 2.8 plots IN_RD against EVENTS. It can be seen that the majority of the HI countries are clustered in group 1, while few countries are located in each the rest of groups. The firms in Luxembourg tend to use knowledge from IN_RD and EVENTS highly for innovation, by contrast, Australian firms use a low level of knowledge from both sources. The firms in New Zealand and Cyprus source knowledge highly from EVENTS but they tend to source lower level of knowledge from IN_RD than other the HI countries i.e. below the average. Within the MI countries, a majority of the countries are distributed proportionately in groups 3 and 4, while fewer countries are in groups 1 and 2. Malaysian and Chinese firms tend to balance both sources of knowledge, in contrary, the firms in Panama use very low level of knowledge from both sources. The firms in Colombia highly source knowledge from EVENTS but they source knowledge from IN_RD below the average.

Figure 2.8 Scatter plot: IN_RD VS EVENTS

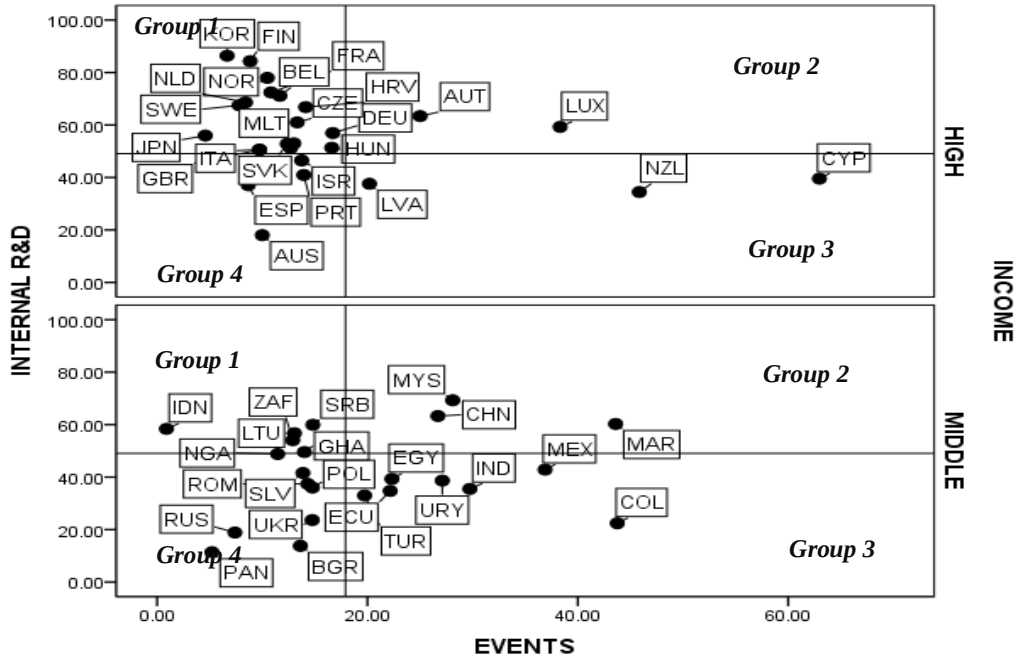
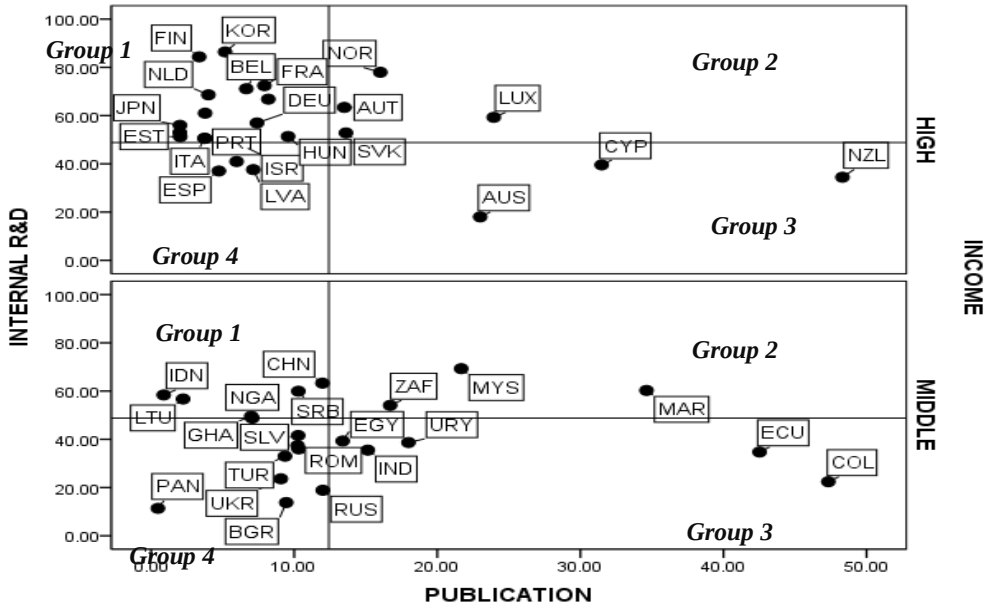


Figure 2.9 Scatter plot: IN_RD VS PUBLICATIONS



In line with figures 2.7 and 2.8, figure 2.9 also shows that manufacturing firms in a majority of the HI countries tend to perform internal R&D to generate knowledge for innovation (group 1). Only a few countries that its firms integrate knowledge from IN_RD and PUBLICATIONS (group 2); source knowledge from PUBLICATIONS (group 3); and do not use both sources of knowledge (group 4). Within the MI countries, more countries are located in both group 3 and 4, while few of them are distributed proportionately in group 1 and 2.

Based on the scatter plots in the figures 2.7, 2.8, and 2.9, conclusions related to different KSS used by manufacturing firms in the HI and the MI countries can be made. Table 2.4 shows how the countries are classified based on their KSS i.e. whether the countries implement internal KSS, external KSS, or integration KSS (i.e. combination between internal R&D and external knowledge).

The firms in the majority of the HI countries tend to generate their own knowledge by performing internal (in-house) R&D activities, by contrast, there are fewer MI countries in which their firms perform such activities (see group 1 in the figures 2.7, 2.8 and 2.9). This activity can be labelled as the internal-KSS or closed innovation strategy. Fewer the HI countries are distributed in groups 2, 3, and 4. More the MI countries are in groups 3 and 4 that may indicates the firms in the MI countries tend to perform external-KSS or to be innovation laggards that source low level of knowledge for innovation from internal and external sources of knowledge.

Table 2.4 Knowledge sourcing strategies (KSS) classification

KSS	IN_RD	Integration	External	Examples
Internal KSS (closed innovation) (group I)	High	-	Low	HI countries: *Belgium, Finland, Korea, and Netherlands*
				MI countries: *Indonesia and Serbia*
Integration KSS (open innovation) (group II)	-	High	-	HI countries: *Luxembourg*
				MI countries: *China and Malaysia*
External KSS (group III)	Low	-	High	HI countries: *Cyprus and New Zealand*
				MI countries: *Columbia*
Innovation laggards (group IV)	Low	-	Low	HI countries: *Australia*
				MI countries: *Panama*

2.4.1.2. Innovation barriers comparison

Table 2.5 presents the output of the descriptive statistics and MWU tests of different innovation barriers faced by manufacturing firms in HI and MI countries. The table clearly shows that the proportion of firms in MI countries face innovation barriers is higher than their counterparts in HI countries. Firms in HI countries experience the greatest innovation barriers related to funding and cost, with ranges from 20% to 27%. By contrast, innovation barriers related to PRIOR_INNOVATION, NO_DEMAND, TECH_INFO and MARKET_INFO are the least important ones, with ranges from 3% to 6%. In line with HI countries, the highest proportion of innovation barriers faced by manufacturing firms in MI countries is cost and

funding related barriers i.e. EXT_FUNDING (28.21%), HIGH_COST (33.35%) and IN_FUNDING (40.18%). The lowest proportion of the innovation barrier is PRIOR_INNOVATION (11.35%).

Table 2.5 Innovation barriers across HI and MI countries (%)

INNOVATION BARRIERS	ALL	HI	MI	Mann Whitney Z (U)
IN_FUNDING	33.7610	27.0225	40.1786	3.16***
EXT_FUNDING	24.1967	20.1860	28.2075	1.95*
HIGH_COST	29.3236	25.6673	33.3455	1.81*
PERSONNEL	18.6238	14.2864	22.7726	-1.29
TECH_INFO	11.2651	5.3052	16.9541	3.09***
MARKET_INFO	10.5810	5.9085	15.2535	2.73***
COOPERATION	11.9187	8.1495	16.3161	2.68***
MKT_DOMINATION	18.8203	14.3290	24.4344	3.38***
UNCERTAIN_DEMAND	18.4071	15.6333	21.1810	-1.67*
PRIOR_INNOV	6.1900	3.0389	11.3464	2.88***
NO_DEMAND	8.0334	4.6811	13.5191	2.97***

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.01; HI: high-income; MI: middle-income

The nonparametric MWU test is used due to some innovation barriers variables violating the required normal distribution (see the K-S test outputs in appendix 2.2). Based on the MWU test, the firms in MI countries significantly face greater levels of all types of innovation barriers (except for PERSONNEL) than those in the HI countries. Internally, manufacturing firms in MI countries face greater barriers related to *cost* (e.g. IN_FUNDING and HIGH_COST), *knowledge* (e.g. TECH_INFO and MARKET_INFO) and *other reasons for not innovating* (e.g. PRIOR_INNOVATION) than their counterparts in HI countries. While externally, firms in MI countries face obstacles related to *cost* (e.g. EXT_FUNDING), *knowledge* (e.g. COOPERATION), and *market* (e.g. MKT_DOMINATION, UNCERTAIN_DEMAND and NO_DEMAND), greater than those in the HI countries. Therefore, the second hypothesis stating that manufacturing firms in the MI countries face higher levels of innovation barriers than their counterparts in the HI countries can be accepted. In the following section, scatter plots are presented to display and compare each country position against diverse types of innovation barriers.

Figure 2.10 shows that the firms in a majority of HI countries, face IN_FUNDING related barrier lower than 40%; by contrast, the firms in the majority of MI countries face such barrier at a level greater than 40%. Firms in Ukraine face the greatest constraint related to IN_FUNDING i.e. more than 60%, in contrary Indonesian manufacturing firms face the lowest proportion of such barrier among the MI group. Figure 2.11 plots EX_FUNDING related constraint faced by the firms in HI and MI groups. Firms in all HI countries face the barrier less at a level lower than 40% as well as the firms in majority MI countries. The firms in Mexico and Indonesia face the highest and the lowest proportion of such barrier, around 60% and 1%, respectively.

Figure 2.10 Scatter plots: Innovation barriers (IN_FUNDING)

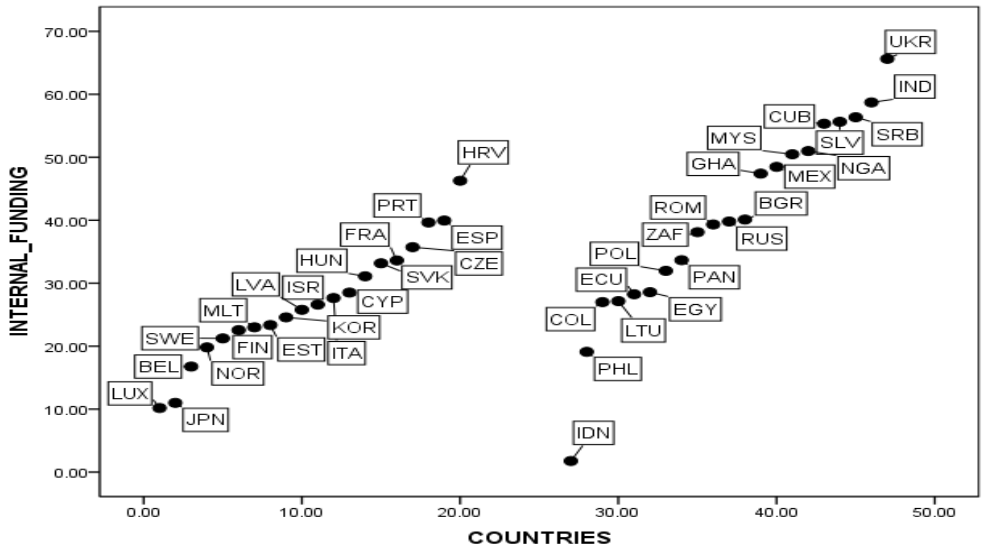


Figure 2.11 Scatter plots: Innovation barriers (EX_FUNDING)

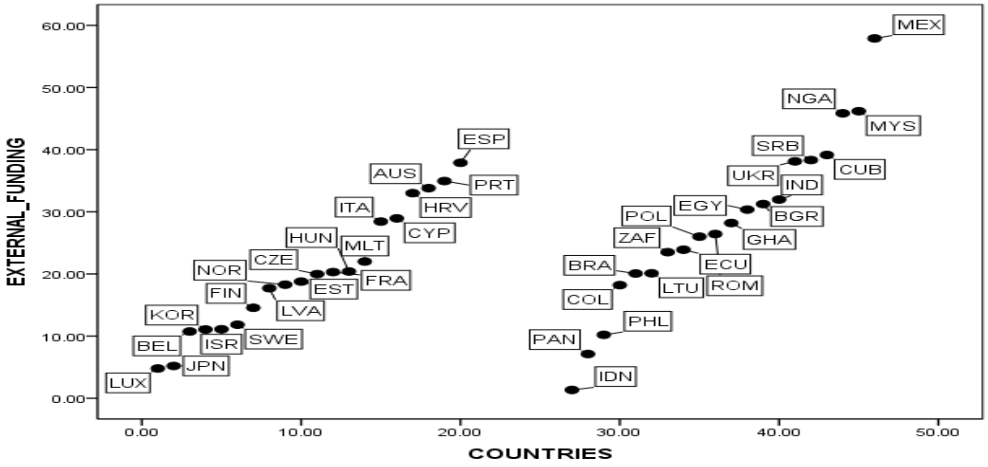
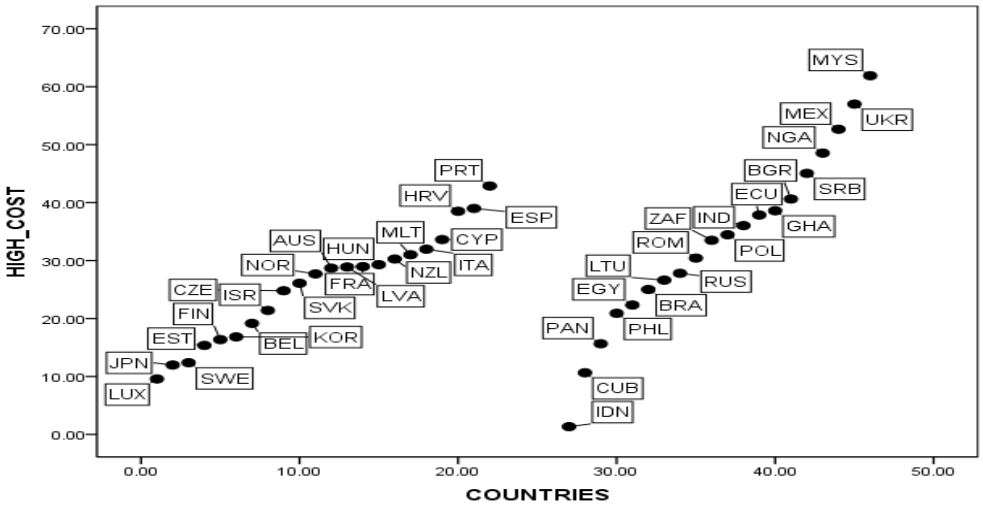


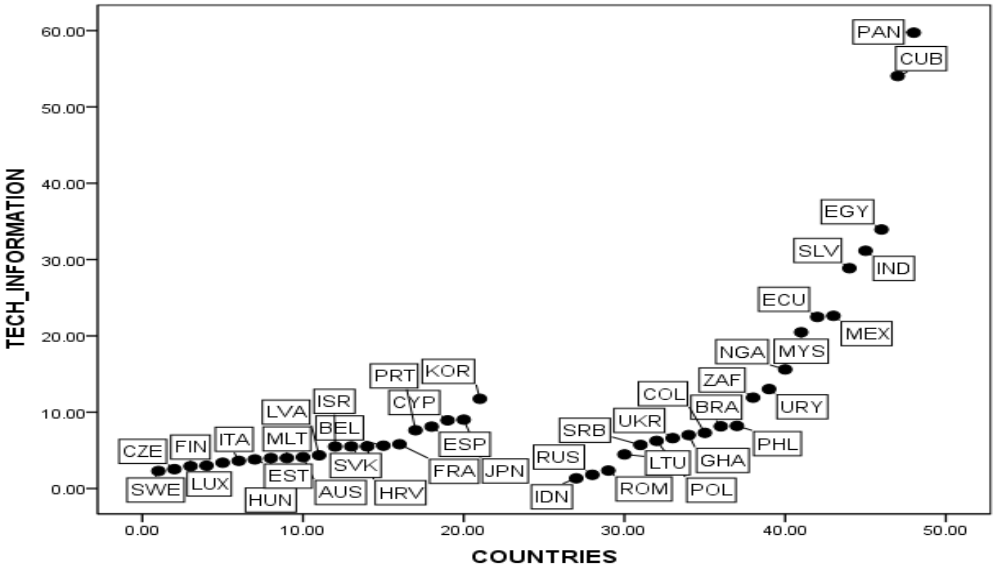
Figure 2.12 displays the countries' position against HIGH_COST related barrier. Among the HI countries, Portugal is an outlier with over 40% of firms facing the HIGH_COST. Among the MI countries, this barrier is reported by 20 to 60% of firms, and Malaysian and Indonesian firms are respectively the extremes, with around 60% and 1%, respectively.

Figure 2.12 Scatter plots: Innovation barriers (HIGH_COST)



Innovation barriers related to cost (i.e. IN_FUNDING, EX_FUNDING, and HIGH_COST) unveils interesting findings. First, firms' proportion in the majority of HI countries that face cost barrier is lower than 40%. Second, within HI countries, countries in which their firms' proportion highly source knowledge from IN_R&D and invest a high proportion of GERD (see figures 2.1 and 2.5) tend to experience a lower level of cost constraint (see figures 2.10, 2.11 and 2.12), for examples Japan and Luxembourg. However, such pattern cannot be found in MI countries. In relation to TECH_INFO barrier, the firms in the majority of HI countries face such barrier at a level lower than 10%. On the contrary, nearly half of the firms in the MI countries face TECH_INFO barrier greater than 10% and the firms in two countries i.e. Cuba and Panama experience the barrier greater than 50%, i.e. outlier countries (see figure 2.13).

Figure 2.13 Scatter plots: Innovation barriers (TECH_INFO)



In line with the TECH_INFO constraint, few HI-based firms report lacking information on market (MARKET_INFO) (see figure 2.14). Based on the MARKET_INFO barrier, the firms in MI countries can be clustered into four groups. The first group consists of a majority of the MI countries in which less than 20% of firms face the MARKET_INFO barrier. The second group members are Malaysia and Mexico, the proportion of the firms in those countries face the barrier ranges from 20% to 30%. In the third group (i.e. India and Egypt), firms that experience such barrier is nearly 40%. The last group singles out Panama, where firms challenges percentage of firms facing this barrier is over 60.

Figure 2.15 shows innovation barrier related to difficulty in finding partners for innovation (COOPERATION). The firms in all the HI countries and a majority of MI countries experience the barrier lower than 20%. Of all countries, Panama is an outlier country, with local firms experiencing the greatest proportion of such barrier, at nearly 60%.

Figure 2.14 Scatter plots: Innovation barriers (MARKET_INFO)

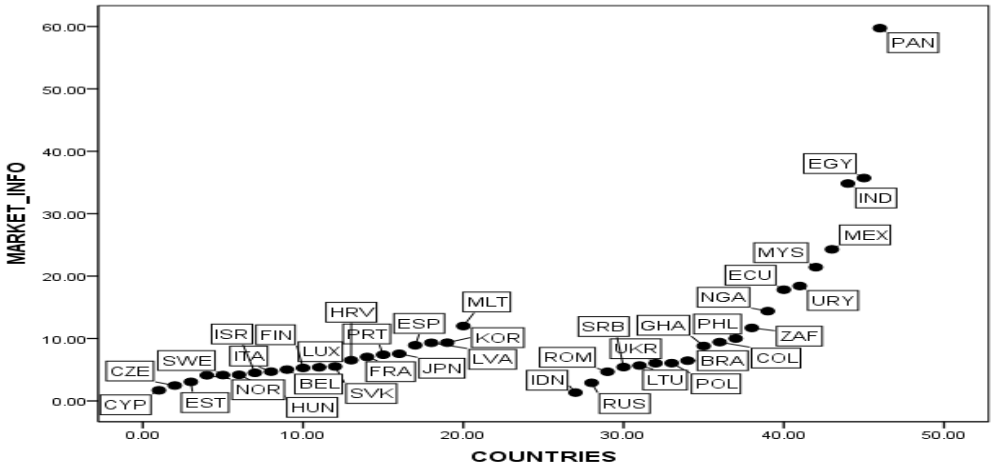


Figure 2.15 Scatter plots: Innovation barriers (COOPERATION)

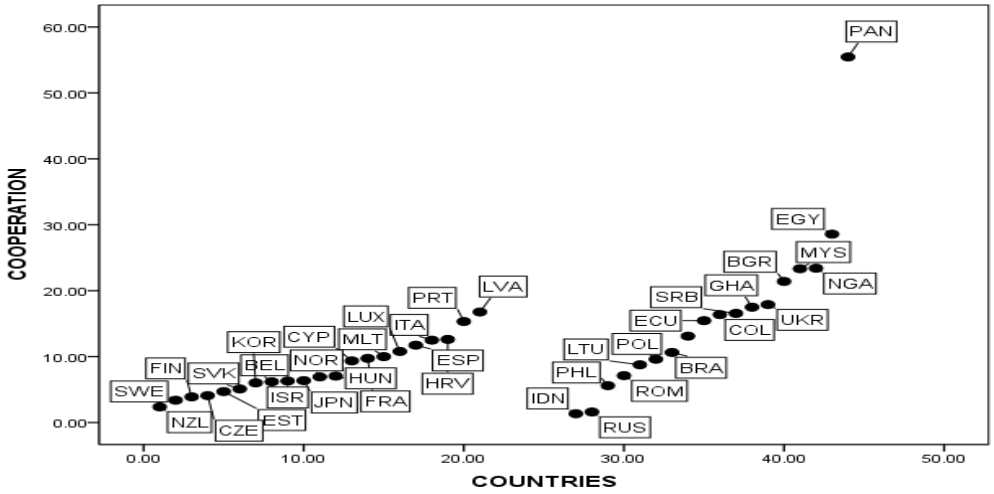


Figure 2.16 displays scatter plot of MARKET_DOMINATION as the hampering factor for innovation. The firms of the top performers of internal R&D and top spenders of GERD (e.g. Japan, Korea and Finland) experience low level of such barrier (lower than 10%). Of the MI countries, the firms in Panama experience the greatest proportion of MARKET_DOMINATION barrier (i.e. around 70%); by contrast, Indonesian firms face the lowest proportion of the barrier (i.e. around 1%).

Figure 2.16 Scatter plots: Innovation barrier (MARKET_DOMINATION)

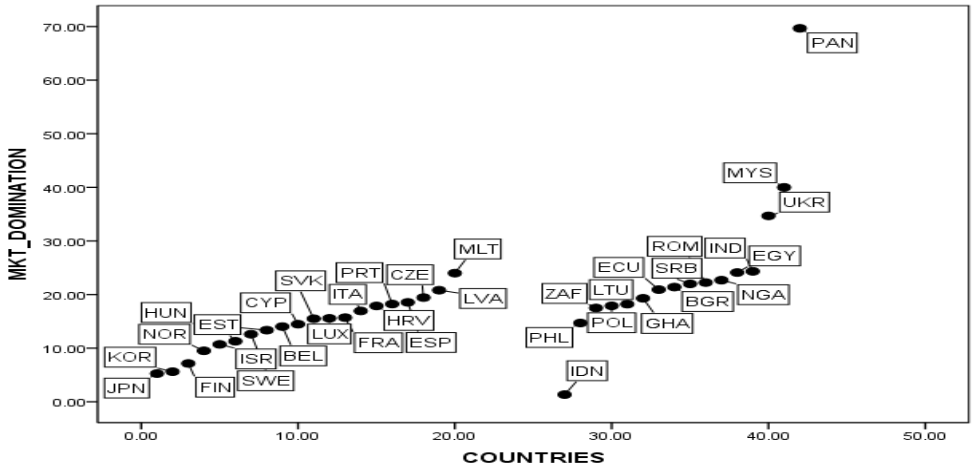


Figure 2.17 displays hampering factor related to UNCERTAIN_DEMAND. Of all sample countries, the firms in Panama face the greatest proportion of the barrier (around 45%); by contrast, Indonesian firms experience the lowest proportion (around 1%). The firms in the majority of the MI countries face the barrier around 10% to 30%. The firms in Egypt, Malaysia, El Salvador, and Panama experience such barrier higher than 30%. While the firms in the majority of HI countries face such constraint less than 20% and the firms in the rest of the HI countries suffer from such constraint around 20% to 30%.

Figure 2.17 Scatter plots: Innovation barriers (UNCERTAIN_DEMAND)

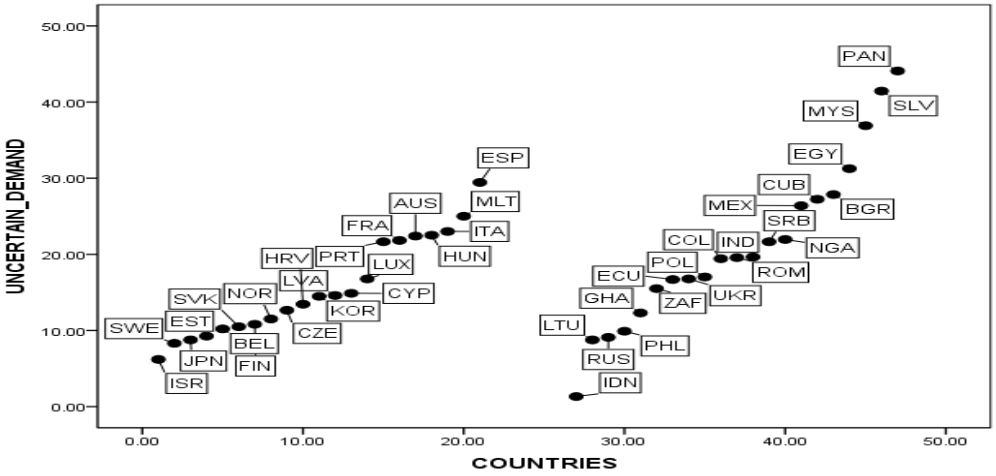
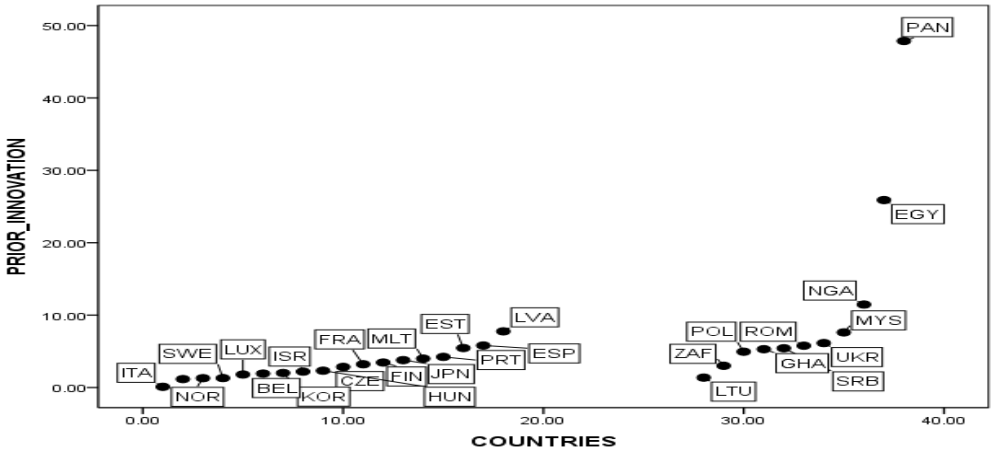


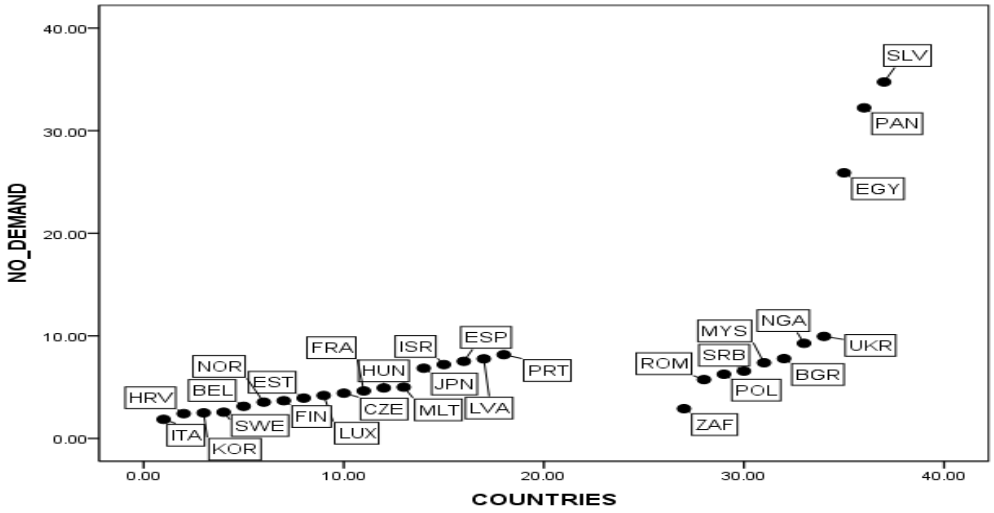
Figure 2.18 clearly shows that firms in all HI countries and a majority in the MI countries experience PRIOR_INNOVATION related barrier lower than 10%. Egypt and Panama are the outlier countries; in those countries, the firms face the proportion of such barrier are nearly 30% and 50%, respectively.

Figure 2.18 Scatter plots: Innovation barriers (PRIOR_INNOVATION)



In line to PRIOR_INNOVATION barrier, figure 2.19 shows that the firms in all the HI countries and the majority of MI countries face NO_DEMAND related barrier lower than 10%. Of countries, the firms in Egypt, Panama and Slovakia challenge NO_DEMAND barrier greater than other countries in the HI and the MI countries, it accounts for around 25% to 35%.

Figure 2.19 Scatter plots: Innovation barriers (NO_DEMAND)



2.4.1.3. Innovation outputs: A cross-country perspective

Table 2.6 presents the innovation outputs that consist of product innovation (PRODINN), process innovation (PROCINN), and the number of patents (PATENT). On average, manufacturing firms in HI countries have higher levels of the three innovation output indicators than their counterparts in MI countries.

Table 2.6 Descriptive statistics & the Mann Whitney-U (MWU) test: Innovation outputs

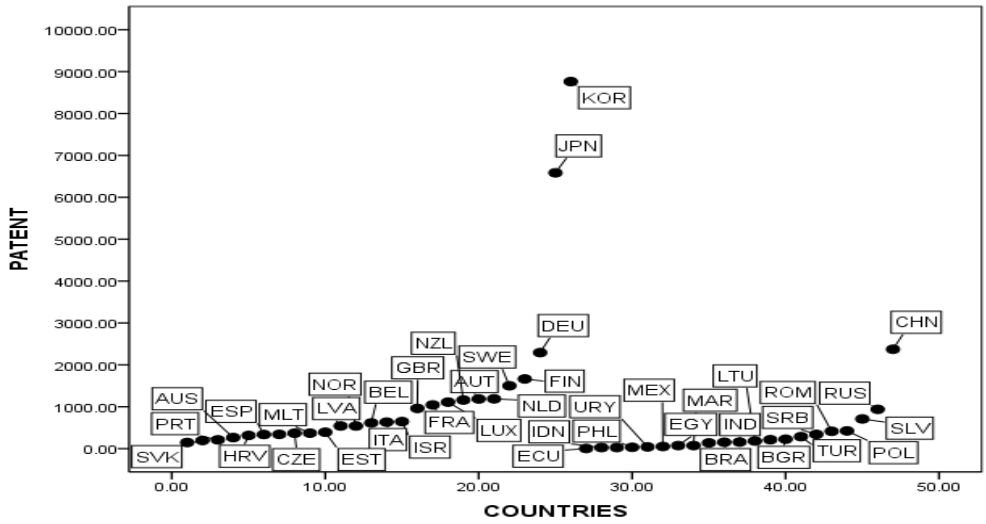
Innovation Outputs	ALL	HI	MI	Mann-Whitney Z (U)
PRODINN[1]	26.8179	28.1558	25.4800	-1.464
PROCINN[2]	26.0267	27.0735	24.9380	-.980
PATENT[3]	856.7872	1,283.9231	327.9524	-3.84***

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.01; HI: high-income; MI: middle-income
[1]Percentage of product innovators in manufacturing firms (total size classes);
[2]Percentage of process innovators in manufacturing firms (total size classes);
[3]Patent application by residents per 100 billion USD GDP (2011 PPP) (by origin)

K-S test shows that the innovation variables violated the required normal distribution, and hence MWU test is used to test the actual difference between the two country groups (see the appendix 2.3). The MWU test shows that the actual difference between the HI and the MI countries is significant only for PATENT; while PRODINN and PROCINN are insignificantly different.

Figure 2.20 displays scatter plot of the countries' position based on the number of patents. Within the HI countries, two countries (i.e. Japan and Korea) produce the highest number of patents (i.e. around 7000 and nearly 9000, respectively). The rest of the HI countries can be divided into two groups. The first group consists of around half the HI countries that produce less than 1000 patents. The second group of the countries generates between 1000 to 2000. In the case of MI countries, all countries are reported to be granted less than 1000 patents except China, with about 2000 patents.

Figure 2.20 Scatter plot: Innovation output (PATENT)



Interestingly, despite the different KSS performed, and innovation barriers faced, by both country groups, the actual difference in the proportion of both product and process innovation are insignificant. However, there is a marked difference in patenting activity that is mainly built on R&D activity in which HI countries

do more. This in line with Cicera's et al., (2015) study that reveals innovation pattern of low-income countries that is based on low R&D innovation investments and lack of cooperation among firms and as a result only resulting the low quality of imitation and survival innovation, and missing returns to innovation.

2.5. Discussion and Conclusion

2.5.1. The variation of knowledge sourcing strategy (KSS)

Empirical findings of this study show that manufacturing firms in the HI and the MI countries have different types and levels of KSS. Knowledge from internal R&D is sourced higher by the firms in the HI countries than their counterparts in the MI countries. While external knowledge from government/public research institutes; conference, trade fairs and exhibitions; scientific journals and trade/technical publications are sourced higher by manufacturing firms in the MI countries. This study also found that based on different types and level sources of knowledge, all countries in both the HI and the MI groups can be classified into four groups. The first group consists of countries that their firms highly employ internal-KSS or closed innovation. The main characteristic of these countries is their firms are heavily generating own knowledge by performing in-house R&D and sourcing lower level of external knowledge. Most countries in this group are from HI or developed countries such as European countries. This finding supports previous studies that argue the higher a country's economic development or the closer a country to technological frontiers, the more likely the country to perform in-house R&D (e.g. Acemoglu et al., 2006, Battisti et al., 2014, Hölzl and Janger, 2014).

The second group consists of countries that their firms tend to balance the usage of both internal and external knowledge for innovation (i.e. integration KSS or open innovation strategy). The external knowledge may be used to complement the internal R&D by countries in this group. However, only a few countries from each country's group that employ the integration KSS, for examples Luxembourg, China, and Malaysia. The third group consists of countries that their firms heavily source knowledge from external and source a low proportion of knowledge generates from inside the firm i.e. external KSS. External knowledge is highly sourced in order to substitute the low level of internal R&D activities and as a result, the firms do not have complementary knowledge to be offered to other firms. Countries in this category of KSS for examples are Cyprus, New Zealand, and Colombia. The last group of countries can be categorised as innovation laggard, in which their firms source low proportion of knowledge from both insides and outside the firms and most of them can be found within the MI countries group such as Brazil and Panama.

2.5.2. The variation of innovation barriers

This study shows that the percentage of the firms in the MI countries face greater innovation barriers internally and externally than those in the HI countries. This finding is in line with previous studies (e.g. Fu et al., 2015, p.31) stating that 'firms in emerging economies face substantial institutional, resources, and

capability constraints in innovation'. Internally, manufacturing firms in the MI countries face greater obstacles related to *cost and findings* (e.g. lack of internal funding, high cost of innovation); *knowledge* (e.g. lack of information on technology and market, and no need to innovate due to prior innovation has been performed).

In relation to financial constraint, the firms in the HI countries that perform internal KSS tend do not have any problems with funding and cost barriers, as indicated by the low proportion on the two barriers. Financial barriers may affect the low level of internal R&D investment, as a result, the firms prefer to source greater knowledge for innovation from external to substitute knowledge that cannot be generated from inside the firms (i.e. internal R&D).

The negative impact of financial constraint on innovation performance has been studied in previous studies. In the case of firms in the MI countries, lack of finance also to be perceived as important obstacles that hamper innovation activities of Malaysian manufacturing firms (e.g. Shiang and Nagaraj, 2011) and drive Chinese firms more open towards external knowledge (Fu et al., 2015). A recent study of innovation activities across developing countries conducted by Cirera et al., (2015) shows that lack of access to finance as indicated by the share of working capital financed by firms' resources to be a factor that hinders R&D activities. Canepa and Stoneman (2008) argue that financial constraint has an impact upon innovation activity, especially for higher technology sectors and smaller firms. Other scholars (e.g. Efthyvoulou and Vahter, 2012) reveal that innovation constraint negatively influence innovation performance and it can be differentiated based on firms' characteristics such as the firms' sectors (production versus service sectors) and the firms' export orientation.

Lack of information on technology information may indicate a common phenomenon in the MI countries. As argued by Cirera et al., (2015) that technological factor in developing countries, for examples, updated capital stock and foreign technological licensing are important determinants of internal R&D activities. Prior innovation may influence the firms in the MI countries for not performing innovation continually as indicated by a lower number of the patent than the HI countries.

Externally, the firms in the MI countries face greater constraints related to *cost and funding* (e.g. lack of external funding to support innovation); *knowledge* (e.g. difficulty in finding cooperation partners), *market* (e.g. established firms dominated market, uncertain demand for innovative products), and *other reason for not innovating* (e.g. no demand for innovation) than their counterparts in the HI countries. The lack of access to external funding such as venture capital and banks may hinder the firms from engaging R&D activities. This finding supports previous studies on innovation barriers, firm openness and innovation performance. Lack of appropriate external source of finance affects the Turkish's firms propensity to innovate (e.g. Demirbas et al., 2011). Market- and institution-related constraints also force Chinese firms to engage with greater depth and breadth of knowledge source from external (Fu et al., 2015). Therefore, it

may be summarised that both internal and external obstacles faced by manufacturing firms in the MI countries, drive them to source knowledge from external, greater than their counterparts in the HI countries.

2.5.3. KSS, innovation barriers, and innovation outputs

Empirical findings of this study show that manufacturing firms in HI and MI countries have different types and levels of sources of knowledge, innovation barriers and number of the patent. Firms in a majority of HI countries tend to predominantly use internal source of knowledge, as indicated by higher firms' proportion that generates own knowledge by performing internal R&D and a lower proportion of the firms that source from external knowledge than those in MI countries. The higher level of internal R&D activities is also supported by a higher proportion of the HI countries' investment on public R&D (GERD) compared to GERD investment in the MI countries. These activities and investment may impact firms in HI countries, and equip them with the necessary capabilities and resources than the firms in MI countries, as reflected in the lower level of various internal and external innovation constraints related to cost and funding, knowledge, and market. In other words, firms in HI countries may in a position to have and maintain better 'absorptive capacity' than those in MI countries. Having such capacity, firms in the HI countries are able to recognise and generate necessary knowledge use for innovation, and eventually are able to exploit the knowledge into better innovation performance i.e. producing higher innovation outputs (proxied by the number of patents) than their counterparts in MI countries. Based on this, HI countries can be labelled as innovation leaders.

Compared to HI countries, it may be speculated that most manufacturing firms in MI countries have limited resources and capabilities to use as inputs for innovation; this condition can be reflected from the greater level of innovation barriers faced by firms in MI countries than their counterparts in HI countries. Therefore, the firms tend not to perform in-house R&D activities and resort to source external knowledge as indicated by the higher proportion of firms that source knowledge from the government or public research institutes; conferences, trade fairs, exhibitions; and scientific journals and trade/technical publications. This in line with Kang et al., (2015) stating that under the condition of limited resources, spending for external technology acquisition will increase. However, performing external KSS alone without balancing it with internal R&D activities, GERD investment, necessary resources and capabilities used for innovation has resulted in low number of the patent. This group of countries, therefore, can be classified as innovation followers.

Apart from patents there is no actual difference in the proportion of product and process innovation between HI and MI countries. Of the MI countries, only China that stands out in the proportion of innovation input such as internal R&D, GEDR, external knowledge, and the number of patents than the rest of the MI countries. Such effort may indicatea that China is in the middle of catching-up to narrow the gap with the innovation leaders. This country may be labelled as an innovation challenger.

Besides the innovation leaders and followers' dichotomy, interesting findings from China, Indonesia and Panama deserve further attention. The findings reveal that China is a good example of a country that employs open innovation strategy in order to catch-up with technology frontiers. On the one hand, the country highly generates own knowledge from internal R&D, and on the other hand, it also highly sources from external knowledge. The country also committed to invest a higher proportion of GERD than other MI countries. The strategy employed may lead to the highest number of patent compared to other MI countries. In the case of Indonesia, the country can be clustered in group I due to the country highly sourcing knowledge from internal R&D activities. In general, the manufacturing firms in the country face a very low level of innovation barriers; ironically the country produces a low level of innovation output (i.e. the number of patents). Based on the Indonesian case, it may be concluded that "when absorptive capacity is not enough to make innovators confident of 'going outside', some firms may not choose an open strategy and instead they become more conservative" (Fu et al., 2015, p.54). Regarding innovation laggard groups, Panama is an interesting case as the country among the innovation laggards group, shows low levels of internal and external knowledge. The country also highly suffers from all types of analysed innovation barriers and hence it may be predicted the country only produce a low level of innovation output (i.e. the number of patents). Lastly, it may be summarised that based on different factors related to innovation input (e.g. internal R&D, GERD), possession of resources and capabilities as well as various innovation obstacles, may influence the firms across HI and MI countries implement different types of KSS and innovation performance.

2.5.4. Study's finding implications

The main challenge that hampers innovation climates in developing countries is the weakness of key elements that build knowledge-based economies, such as levels of education attainment, the business environment and the information infrastructure (Aubert, 2005). In addition, poor performance of many developing countries in accelerating technological learning process can be analysed from problems in the supply side: funding of R&D and incentive for private firms to perform research and therefore 'it seemed natural for governments to place such research in the public sector' (Rosenberg, 2013, p. 285). Specific weaknesses related to knowledge in developing countries is 'there is a general a limited research community, operating usually in an ivory tower, and a university system poorly connected to local realities, particularly to labour market needs and opportunities' (Aubert, 2005, p. 10). In addition, a particular challenge for developing countries in the technological knowledge production consists of incremental change instead of using advanced technology frontier that derives heavily from R&D activities (Wamae, 2009).

Based on a study on innovation strategy of three BRICS countries i.e. Brazil, India and China, (Dahlman, 2010) proposed innovation strategies for developing countries that may be extended to the context of this study. Acquiring and using existing knowledge, such as absorbing global knowledge from a trade, foreign direct investment, technology licensing, copying and reverse engineering, is a key priority for all developing countries as it is less costly and less risky compared to creating new knowledge (Dahlman, 2010). As MI countries face higher levels of innovation barriers, the success of innovation strategies is critically depending on the support from countries' institutions and the institutions' capability (e.g. capabilities to assess, to acquire, and how to adapt the global knowledge to local conditions) (Dahlman, 2010) and includes the involvement of people in the institutions. Disseminating and making effective use of existing knowledge (i.e. either knowledge brought from abroad or developed locally) in the country is another priority for all developing countries and this requires support from public policies on knowledge' dissemination and use (Dahlman, 2010). As public resource in developing countries is limited, the next priority is allocating and managing the limited sources effectively, this includes mapping the government's area that must be supported by limited sources (Dahlman, 2010). In relation to R&D, encouraging public sectors to perform R&D is another crucial issue that currently dominated by the public sectors in order to keep up to date the new development and to perform cutting edge research in important areas to support their competitiveness (Dahlman, 2010).

Admittedly, this study has several limitations. First, this study only focuses on one period and prevents concluding on cause and effect relationships. Therefore, future research should address this limitation by employing longitudinal data to portray the changes of knowledge sourcing strategies over time. Second, only small number of countries used in this study. A high number of countries could be used to perform causality analysis, e.g. using multiple regression analysis, of knowledge sourcing strategies across high- and middle-income countries. Lastly, this study concentrates on manufacturing firms, and some future analysis could compare manufacturing and service firms.

CHAPTER 3 – PAPER 2

HOW KNOWLEDGE IS SOURCED, TRANSFORMED AND EXPLOITED IN THE INNOVATION VALUE CHAIN: FIRM LEVEL ANALYSIS OF INDONESIAN MANUFACTURING FIRMS

3.1. Introduction

Innovation plays important roles at micro and macro levels. At the micro (firm) level, "innovation is widely considered the lifeblood of corporate survival and growth" (Zahra and Covin, 1994, p. 183; Amara and Landry, 2005). Evidence has shown that innovation is the main driver of prosperity, growth and sustainment of high profits for firms (e.g. Christensen, 1997; Drucker, 1988). Innovation's role as an important driving force for economic development is widely acknowledged. At the macro level, innovation is also considered the key success factor for increasing the economic output and productivity of nations (Akman and Yilmaz, 2008).

Interest in innovation studies has been increasing in general, with no exception in the case of developing countries. However, innovation in the context of developing countries cannot necessarily be explained using the same concepts applied to developed countries, because developing countries are subject to different challenges in terms of the capital, infrastructure, intellectual and analytical foundations of innovation system analysis (Choi and Williams, 2013; Lorentzen, 2010; Metcalfe and Ramlogan, 2008; Mytelka, 2000). Silveira (2001) emphasises that it is important to study innovation in developing countries because most theories, approaches, mechanisms and technical changes associated with innovation that affect managerial practices and skills were developed based on evidence from developed countries. The relevancy and adaptability of any model, framework or construct of innovation studies that was developed, built and tested in developed countries needs to be re-evaluated prior to being implemented in developing countries. This study aims to extend previous studies of innovation value chains (IVC) conducted in developed economies, such as North America and Europe (Hansen and Birkinshaw, 2007), Ireland (Roper et al., 2008) and the UK (Battisti and Stoneman, 2013; Ganotakis and Love, 2012; Love et al., 2011), by using innovation survey data of manufacturing firms in the developing economy of Indonesia. As suggested by Roper et al. (2008), it is of considerable interest to compare IVC studies across different national boundaries.

According to Hansen and Birkinshaw (2007, p.122), the IVC is "a sequential, three-phase process that involves idea generation, idea development, and the diffusion of developed concepts". The IVC concept was derived from innovation research projects which interviewed 130 executives from 30 multi-national firms in North America and Europe. Extending Hansen and Birkinshaw's (2007) work, innovation survey-based IVC studies were conducted by other scholars (e.g. Battisti and Stoneman, 2013; Doran and

O'Leary, 2011; Ganotakis and Love, 2012; Love et al., 2011; Roper et al., 2008; Roper and Arvanitis, 2012). Following these scholars, this study aims to investigate the IVCs of knowledge sourcing, transformation and exploitation activities performed by Indonesian manufacturing firms.

This study focuses on the IVC in Indonesia context because to date, no previous study has looked at the IVC based on data derived from innovation surveys of Indonesian firms. Previous studies that investigate knowledge sourcing and using activities are limited to case studies in specific industries. For instance, case studies have covered collaboration and innovation adoption in small-scale industry clusters (e.g. Sandee and Rietveld, 2001); innovation and information flow in small-scale cottage industries in a rural area (Kristiansen, 2002); sources of knowledge in small furniture industries (Van Geenhuizen and Indarti, 2005); social network and innovation of SMEs in handicraft industries (Brata, 2011); and innovation and cooperation activities of SMEs in food processing industry clusters (Najib and Kiminami, 2011). These studies reveal the following important issues such as the most common innovation adopted is product innovation; collaboration among producers (inter-firm cooperation) in SME clusters plays an important role in producers' innovation activities; for traditional knowledge sources such as in-house learning by doing and experiment, customers and competitors are the main knowledge sources in the innovation process; and factors that hamper innovation activities are lack of access to information on the market, lack of advanced technology, lack of funding for innovation activities and insufficient social capital development. Another example of knowledge sourcing is a qualitative study that investigates the role of academia as the external source of innovation in the Indonesian automotive industry (Aminullah and Adnan, 2012). That study found that consumers and competitors are the main sources of innovation in the Indonesian automotive industry, while universities and academia make weak contributions to innovation. Therefore, this study intends to address previous studies' imbalance and to provide a new empirical contribution to the understanding of IVC activity based on a firm-level analysis of Indonesian manufacturing firms. Furthermore, this study also intends to build an IVC model based on innovation activities of the Indonesian manufacturing firms that encompass the three IVC activities of knowledge sourcing, transformation and exploitation. From a practical perspective, findings of this study are expected to be used by policy makers at the government and firm levels to identify innovation activities as well as to detect any weak links in the IVC. Using the information gained, relevant innovation policy and strategy can be formulated to foster innovation in Indonesia. Accordingly, innovation measurement must be conducted to support any relevant strategy and policy that involves interconnectedness among policy, research and statistics to shed light on strategy and policy (Sloan, 2006). To achieve this objective, a quantitative research method is employed, and a dataset from the Indonesia Innovation Survey (IIS) 2011 is used and analysed.

This study differs from previous IVC studies in several ways. *First,* in this study, a wide range of sources of knowledge is used. The sources include (1) R&D activities (internal and external R&D); (2)

informal knowledge gained from market/commercials networks, scientific institutions, associations and open sources; and (3) formal cooperation with various external partners. As argued by previous scholars, sourcing knowledge from diverse sources can increase the degree of innovation novelty (Amara and Landry, 2005) and complicate replication to generate sustainable competitive advantage (Henderson and Cockburn, 1994).

Second, factors that may hinder the success of the IVC such as innovation barriers are investigated. Despite recent growth in research interest on innovation barriers, very limited insight on linking innovation barriers to IVC activities has been generated, with one exception (e.g. Doran and O'Leary, 2011). Previous innovation barrier studies tend to focus mainly on the impact of financial constraints on innovation performance (e.g. Canepa and Stoneman, 2002, 2008; Efthyvoulou and Vahter, 2012; Ferrando and Ruggieri, 2015; Mohnen et al., 2008; Savignac, 2006) and on the factors influencing perceptions of the importance of obstacles (e.g. Baldwin and Lin, 2002; Galia and Legros, 2004; Iammarino et al., 2009).

Third, non-technological or wider innovation classifications such as organisational and marketing innovation are assessed, while most innovation surveys based on IVC studies in developed countries tend to focus on technological innovation such as product and process innovations (e.g. Doran and O'Leary, 2011; Ganotakis and Love, 2012; Love et al., 2011; Roper et al., 2008; Roper and Arvanitis, 2012). As argued by Battisti and Stoneman (2010), joint adoption of technological and wider innovation plays a more central role than relying on technological innovation, as shown in the majority of the innovation literature. In addition, in the context of developing countries, innovation activities tend to focus on the market rather than on the technology (Wamae, 2009). This focus is in line with the innovation activities in developing countries that emphasise minor and incremental changes to existing products or processes as well as innovative approaches to organisation and marketing as major parts of innovation (OECD and Eurostat, 2005). Therefore, it is expected that this study will provide different findings compared to the existing IVC studies.

The following research questions related to IVC activities are addressed in this study:

1. To what extent are the various knowledge sources used by Indonesian manufacturing firms?
2. To what extent are the various knowledge sources used in the knowledge transformation activities associated with diverse types of innovation?
3. To what extent do the different types of innovation adopted by Indonesian manufacturing firms influence firm performance?

The remaining sections of this study are organised as follows. The next section, Section 3.2, presents the conceptual foundation and hypotheses related to IVC activities. In this section, the distinction among knowledge sourcing, transformation and exploitation activities is discussed. Section 3.3 explains data and methods used in this study and describes the data, variables and methods for testing the proposed

hypotheses. Section 3.4 reports the results and analyses to what extent the proposed hypotheses have been confirmed. The concluding section, Section 3.5, contains the discussion and conclusions.

3.2. Conceptual Foundation and Hypotheses Development

3.2.1. The IVC model of Indonesian manufacturing firms

Previous models of the innovation process that have been developed in industrially advanced countries include Rothwell's (1994) five generations of the innovation process, a stage-gate model of innovation (Cooper, 1989) and the funnel model (Wheelwright and Clark, 1992). However, none of these models attempts to deal with the issue of developing countries that must catch up to the technology frontier, because in the catch-up case, innovation occurs based on minor improvements to existing processes and product designs (Hobday, 2005). Therefore, the models may not be relevant to the Indonesian context.

Other scholars have also developed innovation models that encompass innovation process stages and key influencing factors that drive the innovation process, for example, the integrated innovation process model (Bernstein and Singh, 2006) and the IVC model (Hansen and Birkinshaw, 2007). However, the integrated innovation process model is limited to one specific industry, the Australian biotechnology industry. In addition, the knowledge exploitation stage is not included in the innovation process stages, therefore, the model cannot be used to measure how successfully knowledge is exploited.

Hansen and Birkinshaw's (2007) IVC model is based on a framework that emphasises interdependence of different phases or links in the innovation process, which means that if any links fail or are weak, those links will affect the whole innovation process regardless of the strength of the other links. However, the framework does not cover any influencing factors that affect IVC success such as innovation barriers and cooperative activities. Using innovation survey data, several other scholars have also developed IVC models (e.g. Battisti and Stoneman, 2013; Doran and O'Leary, 2011; Ganotakis and Love, 2012; Love et al., 2011; Roper et al., 2008). However, their models tend to focus on internal R&D activity and a limited number of external linkages, such as market and public R&D, as the sources of knowledge. In addition, cooperation activities and a wide range of factors that hinder innovation activities are not included in their models. Lastly, their models focus on technological innovation such as product and process innovation, while this study considers wider sources of innovation and includes analysis of non-technological innovation such as organisational and marketing innovations.

There have been several attempts to link innovation models developed for industrialised, advanced countries to the case of developing countries. For example, Lee at al. (1988) developed a new model includes the catch-up process for developing countries in the following stages: mature technologies, during the transition and in the fluid stages as they progress in their capabilities. Kim (1997) developed a model for Korean firms based on Utterback and Abernathy's (1975) model that consists of three stages: acquisition, assimilation and improvement of foreign technology. However, these models focus on the

process of how foreign technology is adopted in the context of a developing country and does not cover issues of how knowledge is sourced, transformed and exploited.

Since Schumpeter (1934) placed innovation at the centre of economic development theory, studies of the innovation process have come a long way. Despite a large number of studies in the area, inconsistency still occurs in the literature and, as a result, it is difficult to draw meaningful conclusions and determine practical implications because studies often confuse industry types, methodologies and theories (Bernstein and Singh, 2006). Srholec (2008) argues that the innovation process is a complex phenomenon that cannot be explained by a single analysis. Therefore, innovation process success should be considered a multilevel phenomenon related to individual characteristics, firms' capabilities and the environment in which they operate. Bernstein and Singh (2006) approach innovation by integrating and presenting a conceptual model that consists of the innovation process as well as organisational and market-related issues.

In this study, development of the IVC model will address the factors covered in the research questions and objectives of this study. As the basis of the model development, the first inquiry deals with the IVC which is comprised of knowledge sourcing, transformation and exploitation activities. The second inquiry includes any factors that influence the success of the innovation process in Indonesian manufacturing firms and will be different from the IVCs in industrially advanced countries.

3.2.2. Knowledge sourcing activity

In the first link of the IVC, knowledge is sourced from both inside and outside the firms (Hansen and Birkinshaw, 2007). Therefore, the main task in this activity is to assemble the knowledge used for innovation (Roper et al., 2008). In terms of the degree of externalisation, Frenz and Ietto-Gillies (2009, p. 1126) explain that internal R&D is the knowledge generated inside a firm, while knowledge from external R&D, from informal and open networks, and from cooperation activities are "external to the enterprise to various degrees, depending on their ownership and the contractual structures of the relationship between our enterprise and the other party or parties to the transfer". Knowledge from external linkages can be differentiated based on the form of access, whether informal or formal, and the knowledge content being transferred (Monjon and Waelbroeck, 2003). Storper (1997) classified formal cooperation as that which involves more formalised interactions among firms. In contrast, informal interactions, which normally involve informal relations, "might explain the spatial concentration of innovative industries and activities" (Tödtling et al., 2009, p. 61).

Informal linkages can include "personal contacts or communities of practice or simply arise in the normal course of business", while formal linkages "can be organised by business organisations such as chambers of commerce, research associations, technology services companies, consultants, universities or public research organisations or sponsored by local, regional or central governments" (OECD and Eurostat, 2005, p. 79). Internal firm capabilities are necessary to access and absorb knowledge from informal

linkages, while formal cooperation activity is associated with the use of knowledge resulting from access to resources and innovative capabilities of partners (Freitas et al., 2011).

Several previous studies have investigated the interaction among sources of knowledge used for innovation activities. One of the main discussions in these studies is whether complementary or substitution relationships exist between internal and external knowledge sourcing strategies in innovation activities. Some scholars argue that studies of such relationships remain unclear and inconclusive (e.g. Hagedoorn and Wang, 2012; Schmiedeberg, 2008). On the one hand, some studies reveal a complementary relationship between internal R&D and external knowledge in knowledge sourcing activities (e.g. Battisti and Stoneman, 2013; Cassiman and Veugelers, 2002, 2006; Hagedoorn and Wang, 2012; Roper et al., 2008; Schmiedeberg, 2008). On the other hand, other empirical studies identify a substitution relationship in these activities (e.g. Hess and Rothaermel, 2011; Laursen and Salter, 2006; Love and Roper, 2001; Xu et al., 2013). In this study, the term 'complementarity' is used interchangeably with 'synergistic', which means that implementation of one strategy increases the marginal returns from another (Milgrom and Roberts, 1995).

In the case of innovation activities in developing countries, Hou and Mohnen (2013) argue that complementarity discussions focus on the relationships between internal R&D and imported technology. Examples of empirical studies that identify complementary relationships in innovation activities in developing countries include the study of technology efforts and technology buying in Brazilian industries (Braga and Willmore, 1991) and a study of internal R&D activities and technology transferred from overseas in Indian firms (e.g. Deolalikar and Evenson, 1989; Katrak, 1989).

Using the World Bank Investment Climate Survey (ICS), a recent study conducted by Hou and Mohnen (2013) investigates the existence of complementary or substitution relationships on the knowledge acquisition strategies in manufacturing industries in low-income and middle-income countries. Complementarity was found in middle-income countries, while a substitution relationship between external technology acquisition and internal knowledge development was found in low-income countries. Poor countries face constraints in financial and human resources (Hou and Mohnen, 2013) and also tend to perform very little R&D (Goñi and Maloney, 2014). Therefore, substitution may be the right strategy.

Turning to the Indonesia context, there are a few insights related to synergistic or substitution strategies in innovation activities performed by Indonesian firms. In general, as in any other developing country, advanced knowledge of technology is accessed by importing from the advanced industrial countries, and the international technology transfer process mostly takes place in the private sector (Thee, 2005) because public support for R&D is minimal (Hill and Tandon, 2010). Thee (2005) identifies two major channels of international technology transfer to Indonesia: (1) a formal or market-mediated channel that includes FDI; technology licensing agreements; imports of capital goods; foreign education and training; turnkey plants; and technical consultancies, and (2) an informal or non-market mediated channel

composed of technical assistance by foreign buyers and foreign vendors; copying or reverse engineering; information from trade journals; and technical information services provided by public agencies.

Apart from imported technology, the use of various sources of knowledge by Indonesian firms has also been studied. For example, Indonesian small furniture firms tend to generate knowledge through in-house learning by experimentation as well as from customers (Van Geenhuizen and Indarti, 2005). Cooperative activity was also found positively related to innovation in a cluster of Indonesian small food processors (Najib and Kiminami, 2011) and small scale roof tile firms (Sandee and Rietveld, 2001). Collaboration within Indonesian small firm clusters is also effective for sharing costs and risks (Sandee and Rietveld, 2001). As an example of an Indonesian high-technology industry, the automotive industry develops innovation mainly from inside the organisation and competitors are the main source of external knowledge to support the creation of new products in a competitive market (Aminullah and Adnan, 2012). On the other hand, universities and public research institutions contribute little external knowledge to the Indonesian automotive industry (Aminullah and Adnan, 2012). Therefore, even though literature that discusses the involvement of external actors as sources of knowledge in the innovation process is scare, a synergistic relationship between internal and external knowledge may exist to some extent. Based on this, a hypothesis related to knowledge sourcing activity in Indonesian manufacturing firms is proposed:

H1 *In knowledge sourcing activities, a synergistic relationship exists between internal R&D and external sources of knowledge.*

3.2.3. Knowledge transformation activity

In the second link of the IVC, different sources of knowledge used in the innovation activities are transformed or converted into different types of innovation (Hansen and Birkinshaw, 2007; Roper et al., 2008). This involves innovation or knowledge production in which the success of knowledge transforming activities relies on the firms' knowledge sources (Griliches, 1992; Love and Roper, 1999). Therefore, the main issue addressed in this stage is the empirical assessment of the comparative impact of various sources of knowledge (e.g. R&D activities, informal knowledge and formal cooperation) on different types of innovations (e.g. product, process, organisational, and marketing innovations). Another issue that is investigated at this stage is the firms' openness and use of external knowledge and how this affects innovation and innovation success. The last issue that is addressed in this stage is that of the various barriers to innovation that may naturally hamper innovation activities performed by Indonesian manufacturing firms and their link to diverse types of innovation.

3.2.3.1 Internal R&D and innovation

Innovation is a complex phenomenon and normally firms use several sources of information simultaneously (Freitas et al., 2011). The link between various sources of knowledge and the adoption of different

innovations has been investigated (e.g. Amara and Landry, 2005; Tödtling et al., 2009; Srholec and Verspagen, 2012). Previous scholars (Amara and Landry, 2005; Todtling et al., 2009) find that advanced innovations that are new to the market need a higher level of extended internal R&D, patent and more knowledge from universities, and research organisations to stimulate and support them. Meanwhile, less advanced innovations, such as business services (Todtling et al., 2009) and market innovations (Amara and Landry, 2005), require knowledge links with less research-based input.

A majority of previous IVC studies in advanced economies reveal that internal R&D activities are positively and significantly associated with innovation adoption (e.g. Doran and O'Leary, 2011; Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). Apart from the IVC studies, other studies in industrialised countries at the firm level show positive links among R&D, innovation and productivity (e.g. Griffith et al., 2004; Griffith et al., 2006; Mohnen et al., 2006). Evidence from developing and newly industrialised countries also shows a positive association between R&D, innovation and productivity, with examples including Argentina (Chudnovsky et al., 2006), Malaysia (Hegde and Shapira, 2007), China (Jefferson et al., 2006) and Taiwan (Yan Aw et al., 2008). Firms that have higher levels of investment in R&D are more likely to introduce technological innovation as was found in Argentina (Arza and Lopez, 2010), Brazil (Raffo et al., 2008) and Bulgaria (Alvarez et al., 2010). Based on this, a second hypothesis is proposed:

H2a Internal R&D positively influences innovation and innovation success.

3.2.3.2 Informal knowledge and innovation

The use of informal knowledge as input for the innovation process comes mainly from external information sources gained without any formal arrangements (Garcia-Torres and Hollanders, 2009). The informal link between certain actors and types of innovation has been investigated in previous studies. Past subjects of investigation have included the role and involvement of *customers* in the innovation process (e.g. Franke and Schreier, 2002; Joshi and Sharma, 2004; Von Hippel and Katz, 2002); key *suppliers* and their roles in product innovation development (Amara and Landry, 2005; Nieto and Santamaria, 2007; Smith and Tranfield, 2005); the role of *competitors* in knowledge transfer and innovation (e.g. Malmberg and Maskell, 2002); and fostering advanced technological innovation (e.g. Gnyawali and Jin Park, 2011). Open source information and knowledge from *scientific publications* proves beneficial for firms (e.g. Caloghirou et al., 2004).

Based on CIS survey data for 13 European countries, Srholec and Verspagen (2012) identify three sources of knowledge used for innovation, namely “a science-based” approach that involves both universities and research institutes; a “client and industry based” approach that combines information from customers, competitors and other firms in the same group; and a “supplier based” approach which relies on information from suppliers. Subsequently, each of these approaches is then linked to one or more types of

innovation. Science-based firms tend to do joint projects with external organisations, client and industry-based firms are more likely adopt more product innovation and supplier-based firms tend to engage in the acquisition of machinery and equipment. Other scholars (Battisti and Stoneman, 2010, 2013) find that there are complementarities in new idea generation and innovation adoption meaning that the generation and adoption of different types of innovation can occur together and, therefore, firms are able to develop different types of innovation simultaneously.

In the case of Indonesian firms, studies of informal knowledge usage for innovation have been conducted and the results show that different sources of external knowledge contribute to diverse benefits for the firms. External actors apart from the market, for example *foreign suppliers*, have very important roles in the development of technological capability and innovation in Indonesian firms (Thee, 2005). *Foreign buyers* also contribute technical and managerial assistance for many Indonesian SMEs (Thee, 2005). *Competitors* support the development of new products in the competitive market (e.g. Aminullah and Adnan, 2012). However, there is no single study in the Indonesia context that links diverse knowledge of innovation and adoption of different types of innovation with innovation success achieved by Indonesian manufacturing firms. In this study, informal knowledge derived from the IIS 2011 is grouped into *market/commercials*, including suppliers, customers, competitors, consultants and commercial labs; *science institutions*, including universities, polytechnic institutes, government R&D and non-profit R&D; *associations*, including industry associations, investors and entrepreneurs; and *open sources*, including events, scientific publications and the internet.

3.2.3.3 Breadth of external knowledge and innovation

"It suggests that different strategies for search can yield different innovative performance outcomes" (Laursen and Salter, 2004, p.1203). Following the work of Cohen and Levinthal (1990), Laursen and Salter (2006) argue that firms' abilities to exploit external knowledge is crucial for innovation performance. Previous studies find that open innovation consisting of breadth and depth external searches in both developing (e.g. Chiang and Hung, 2010; Kafouros and Forsans, 2012) and developed economies (e.g. Ahn et al., 2014; Battisti et al., 2014; Ebersberger et al., 2012; Laursen and Salter, 2006; Laursen et al., 2007; Salge et al., 2012) reveal a significant and positive relationship between openness and innovation performance with variations in the relationship due to differences in external search breadth versus depth and the use of domestic versus overseas sources of knowledge.

Despite such positive associations between external search breadth and depth and innovation performance, some studies reveal that "over searching" on external knowledge tends to diminish innovation performance. For example, Laursen and Salter (2006) find that the relationship between openness and innovative performance is curvilinear, taking an inverted U-shape. Using panel data on Finnish firms, Laursen et al. (2007) reveal that the relationship between firms' openness to external knowledge and their

profitability is a curvilinear, showing that there are decreasing returns to the external knowledge searching activity. A curvilinear relationship between open innovation and innovation performance was also found in the context of small firms. For example, evidence of such a relationship can be found in small Irish firms (Vahter et al., 2012). In the second stage of the IVC, the influence of the breadth of informal knowledge on innovation and innovation success is also tested.

3.2.3.4 Formal cooperation and innovation

This section discusses how knowledge gained from cooperation among diverse actors affects the adoption of innovations. According to Hagedoorn (2002), formality of firms' collaborations and cooperative agreements involves management approval and commitments that are documented as memorandums of understanding (MoUs) and technical agreements. It is argued that, at a basic level, the reason that firms cooperate is that they do not have the necessary resources internally or that they want to reduce any risk related to innovation (Tether, 2002). Most innovation involves several actors. Scholars of innovation network theory (Baptista and Swan, 1998) argue that only a few firms perform innovation on their own and the ability to build strong links with external parties is important in the introduction of new products into the market. As a result, "innovation is seen as becoming increasingly distributed, as fewer firms are able to go it alone in technological development" (Tether, 2002, p. 947).

A major study reveals that the determinants of R&D cooperation depend on the type of R&D cooperation and the cooperating partners (Belderbos et al., 2004). "The literature suggests that an analysis of different types of cooperation strategies should take into account the different possible aims of (collaborative) R&D efforts" (Belderbos et al., 2004, p.1480). Incremental innovation that is supported by cooperative activities aims to reduce cost and lead to labour productivity while R&D activities combined with client cooperation are more likely to lead to sales expansion through innovative products (Belderbos et al., 2004b).

Several empirical studies find different impacts of cooperation activities on different types of innovation and innovation performance. Positive impacts of cooperative activities on innovation performance have been documented for sales of innovative products (e.g. Faems et al., 2005; Klomp and van Leeuwen, 2001; Lööf and Heshmati, 2002) and sales growth (e.g. Belderbos et al., 2004; Cincera et al., 2003). Previous studies also reveal that different cooperative partners are linked to different types of innovation and innovation performance, but the findings are ambiguous. Firms' propensities to engage in cooperative arrangements impacts the novelty of innovation introduced by the firms. When firms intend to introduce new market innovations, they tend to engage in cooperation arrangements (Tether, 2002). A logical reason behind this is that higher levels of innovation require greater information exchange (Tether, 2002). On the basis of German manufacturing firm data, Fritsch and Lukas (2001) find that cooperation with partners such as suppliers tends to provide relatively low value added to turnover, while customers are

associated with product innovations. Using data from two waves of the Dutch CIS (1996, 1998), Belderbos et al. (2004b) investigated the impacts of four types of R&D cooperative partners: competitors, suppliers, customers, universities and research institutes on the performance measures of labour productivity and sales of new product innovations. They find that suppliers and competitors significantly influence labour productivity growth while universities, research institutes and competitors positively affect growth in sales per employee of products and services new to the market.

Evidence from developing countries shows that formal cooperation supports innovation. Evidence from a Chinese science park in the most innovative region in China reveals that cooperation with foreign partners supports ideas for marketing new products, while universities support design of new products (Liefner et al., 2006). In Chinese SMEs, significant positive relationships are found between innovation performance and inter-firm cooperation and cooperation with intermediary institutions and research organisations. In contrast, an insignificant relationship is found between government agencies and innovation performance (Zeng et al., 2010). In Tanzania, Goedhuys' (2007) study reveals that cooperation supports innovation activities performed by local firms even when firms invest less in new machinery, training and R&D. In Indonesia, cooperation is useful in sharing risk and cost within SME clusters (e.g. Najib and Kiminami, 2011; Sandee and Rietveld, 2001).

In this study, cooperating partners derived from the IIS 2011 can be grouped into: *firm group* (firms within the enterprise group), *market/commercials* (suppliers, competitors, consultants and commercial labs), *science institutions* (universities and government R&D) and *associations* (industry associations). To date, there are no existing studies that provide insights into the frequency with which Indonesian manufacturing firms use informal knowledge versus formal cooperation for innovation. Therefore, this study will address this question and hence, another hypothesis is proposed:

H2b Different levels of informal knowledge and formal cooperation influence innovation adoption differently.

3.2.3.5 Innovation barriers and innovation

Factors that hamper, block or delay innovation activities, often called innovation barriers, have been studied for more than 30 years, but evidence based on original data from developing countries such as those in South America and Africa is sparse (Hueske and Guenther, 2015). A number of studies that cover innovation barriers in different developing countries have been conducted, for example, on Brazil (e.g. Kuhl and da Cunha, 2013), Cyprus (e.g. Hadjimanolis, 1999), China (e.g. Fu et al., 2015, Savitskaya et al., 2010, Xie et al., 2010, Zhu et al., 2012), Malaysia (e.g. Shiang and Nagaraj, 2011) and Turkey (e.g. Demirbas et al., 2011). Surprisingly, there is no existing study that specifically discusses innovation barriers in the context of Indonesian firms. Common themes from these studies are: classifying any factors that hamper innovation activities; rating the importance level each type of innovation barrier according to firm

size, technology intensity and innovativeness; investigating complementarity between obstacles encountered; and innovation barriers against open innovation strategies in China (e.g. Fu et al., 2015, Savitskaya et al., 2010). However, there is no factor that links innovation barriers to different innovation modes adopted by firms. Therefore, it is expected that the findings of this study will uncover the link between the innovation barriers encountered and the innovations adopted in the context of a developing country.

Previous scholars have classified constraints related to innovation activities in various ways: internal (endogenous) versus external (exogenous) barriers (e.g. Piatier, 1984); revealing versus deterring barriers (e.g. D'Este et al., 2012); the EOGI barrier model (Hueske and Guenther, 2015); and five factors related to innovation barriers, including cost, knowledge, market, institutional and other reasons that are classified in the 3rd edition of the Oslo Manual (OECD and Eurostat, 2005). A classification that is rarely discussed in the literature is proposed by D'Este et al. (2012), namely revealing and deterring barriers. The term revealing barrier refers to 'the firm's awareness of the difficulties involved as a result of engagement in innovation activities pointing to a 'disclosing' or 'learning' outcome based on direct experience, and deterring barriers are seen by firms as being insurmountable' (D'Este et al., 2012, p. 482).

The majority of literature on innovation barriers focuses on financial constraints and their impacts on innovation performance (e.g. Canepa and Stoneman, 2002, 2008; Efthyvoulou and Vahter, 2012; Mohnen et al., 2008; Savignac, 2006). Financial constraints significantly impede French manufacturing firms that undertake innovative projects and, as a result, the firms without financial constraints show the best profile of economic performance, financial structure and risk. In contrast, non-innovative firms facing financial constraints have the poorest profiles (Savignac, 2006). Furthermore, financial constraints are found to be more important than any other innovation constraints (Canepa and Stoneman, 2002) and have greater impact on postponing innovative projects, but not on abandoning innovation projects (Canepa and Stoneman, 2002; Mohnen et al., 2008; Savignac, 2006).

Guijarro et al. (2009) attempt to link innovation barriers and diverse types of innovation adopted by Spanish firms. They find that barriers have differential impacts on product, process and management innovation. Process and management innovation are negatively affected by insufficient financial and human resources, while barriers related to the external environment are positively affected the two types of innovation. A wide range of innovation barriers have been linked to firms' propensities for innovating products or processes (Silva et al., 2008). They find that constraints such as lack of financing sources, lack of skilled personnel and lack of customers' responsive to new products increase the cost of innovation, significantly affecting the propensity for innovating the new product or process (Silva et al., 2008).

In the case of developing countries, the effects of innovation barriers on the propensity to innovate are found in Hadjimanolis' (1999) and Shiang and Nagaraj's (2011) studies. On the basis of innovation data on Cypriot small-medium firms, Hadjimanolis (1999) finds that the higher the importance of external

barriers perceived by the SMEs' owner/manager, the higher the innovativeness. A possible reason is that, despite facing important barriers, innovative firms are able to find ways to overcome the barriers. The same finding can also be found in Malaysian manufacturing firms that engage in innovation activities, as they are more likely to face greater barriers (Shiang and Nagaraj, 2011).

In Indonesia, previous studies have linked innovation barriers to a wide range of Indonesia's development issues. Financial constraints are found to be the most important barrier that hinders Indonesian furniture SMEs in accessing knowledge to be used for innovation processes (Van Geenhuizen and Indarti, 2005) and also found to be the main constraint faced by the majority of Indonesian SME owners (OECD, 2010). Knowledge and skills related barriers also hamper technological development in Indonesia. According to Okamoto and Sjoholm (2001), Indonesia suffers from a lack of technological development driven by low R&D budgets and lack of education. These weaknesses have forced the country to rely on foreign firms to enhance its technological capability. A case from the Indonesian turbine industry finds that knowledge and skill barriers hamper imported technology transfer processes (Soekarno et al., 2009). The low levels of scientific cooperation among Indonesian technology producers, internal R&D activities and technology absorptive capacity also deter Indonesian firms from performing innovation activities (Lakitan, 2013).

Barriers related to institutions have also been discussed previously. A managerial constraint exists in the Indonesian aircraft industry that affects the technological accomplishments and performance of the industry (McKendrick, 1992). Even though Indonesia achieved rapid growth from 1970 to 1996, the country faced institutional problems such as corruption (Hofman et al., 2004). Challenges also arise when Indonesia attracts foreign firms to invest in the country due to the relatively poor business environment, the quality of institutions, the lower levels of education of the labour force and poor infrastructure (Lipsey and Sjoholm, 2011). Based on this analysis, a hypothesis is proposed:

H2c Innovation barriers encountered by firms negatively affect innovation and innovation success.

3.2.4 Knowledge exploitation activities

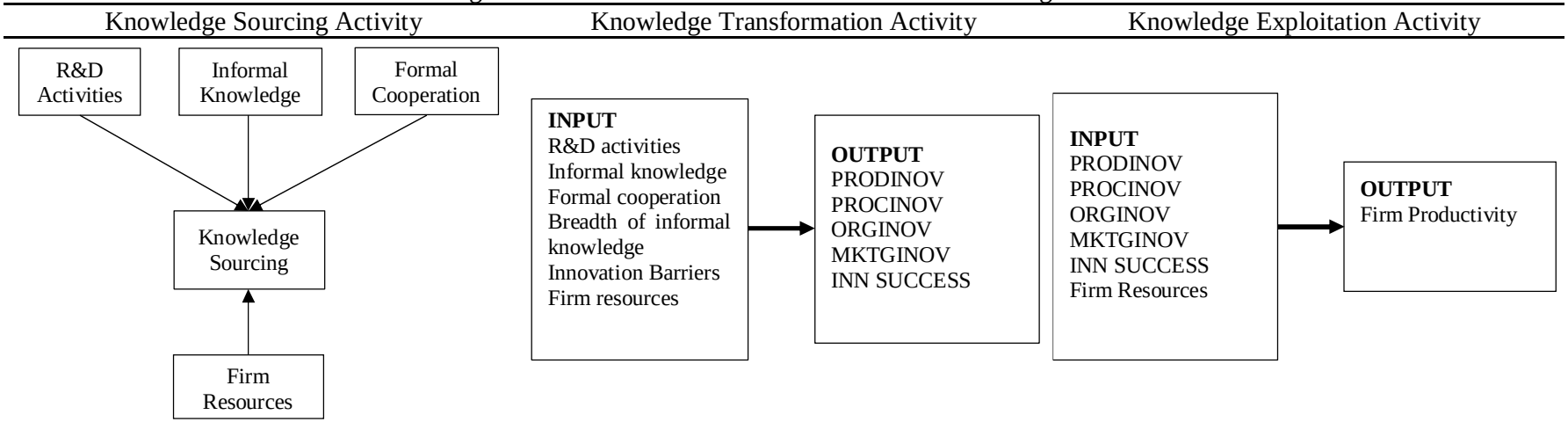
The final link in the IVC is knowledge exploitation that generates value for the firm. Starting with the work of Geroski et al. (1993), previous scholars such as Ganotakis and Love (2012a), Love et al. (2011) and Roper et al. (2008) argue that, in the knowledge exploitation stage, firm performance is affected by innovation output as the result of codified knowledge gained through knowledge sourcing activities. They state that innovation output needs to be determined prior to knowledge exploitation. Therefore, the main interest at this stage is how firms gain business productivity or profitability from the exploitation of adopted innovation. In this study, productivity (indicated by total sales/number of employees) is used to measure how innovation affects overall firms' performance. Prior IVC studies find that innovation output in the form of product and process innovation significantly and positively influences innovation performance as

measured by sales and employment growth (Ganotakis and Love, 2012; Roper et al., 2008). Surprisingly, both a negative impact (e.g. Roper et al., 2008) and no relationship (e.g. Ganotakis and Love, 2012) of product innovation success on productivity have been found. Therefore, in this study, the involvement of wider innovation, specifically organisational and marketing innovation, is expected to provide a different view compared to previous IVC studies. An additional hypothesis may be proposed:

H3 *In knowledge exploitation activity, innovation and innovation success positively affects a firm's performance.*

Figure 3.1 shows the IVC model that represents the three stages of IVC of Indonesian manufacturing firms. In the first stage, three groups sources of knowledge (i.e. R&D activities, informal knowledge and formal knowledge) sourced by the firms as well as firm resources that may affect knowledge sourcing activity are displayed. In the second stage, the three groups of knowledge and firm resources are used as the input for knowledge transformation activities. The innovation process can be seen as the transformation of tangible and intangible innovation inputs or knowledge capital, including technology; equipment; human capital; scientific and creative capital; and innovation activities into innovation output such as products, processes, organisational and marketing innovations (Cirera et al., 2015). The firm's openness to a wide range of external knowledge (breadth) as well as factors that may hinder the knowledge transformation activity (innovation barriers) are also presented. Different types of innovation and innovation success are the outputs of the knowledge transformation activity. In this case, inputs to the activity, such as knowledge and firm resources, are treated as the independent and control variables, respectively, with the outputs from the activity are the dependent variables. In the last stage, the knowledge exploitation activity, types of innovation and innovation success as well as firm resources used as input to the activity are treated as independent and control variables, respectively. The output from the last activity is firm productivity and this variable is treated as the dependent variable.

Figure 3.1. The IVC Model of Indonesian Manufacturing Firms



Notes:
PRODINOV=product innovation; PROCINOV=process innovation; ORGINOV=organisational innovation; MKTGINOV=marketing innovation; INNOVSUCCESS=innovation success (proportion of innovative products new to the market); PRODUCTIVITY=total sales/number of employees

3.3. Data and Methods

3.3.1. Data

The empirical analysis in this study is derived from the Indonesia Innovation Survey (IIS) 2011 that covers 2009-2010. In terms of firm size, the IIS 2011 surveyed only medium (20-99 employees) and large (more than 99 employees) Indonesian manufacturing firms. The surveyed firms are classified based on the International Standard Industrial Classification (ISIC) Rev. 3.1 (see Table 1 for details). Multi-stage random sampling was used to collect data from 1,500 firms and a total of 1,375 questions were successfully collected. Of the returned questionnaires, 1,179 were usable. Face to face interviews with R&D or production managers were conducted to collect the data. The IIS 2011 used the Oslo Manual (OECD/Eurostat, 2005) as the guideline for collecting and interpreting innovation data and adjustments were made to facilitate innovation activities in Indonesia that may differ from those in developed economies. For example, the innovation activity and internal sources of knowledge variables in the IIS 2011 have broader categories than the same variables in the UK CIS.

Table 3.1 shows the distribution of the sample and population based on types of industry. In the case of manufacturing sectors, the following are among the top five industries: food and beverage (26.21%), textiles (10.69%), clothing (8.99%), furniture (8.99%) and non-metallic mineral products (8.31%). The lowest proportion was from coke, refined petroleum products, nuclear and fuel (0.08%) and office accounting and computing machinery (0.08%) industries. Table 3.2 clearly shows that the sample consists of 76.68% (904 firms) medium firms versus 23.32% (275 firms) large firms. The food and beverage industry represent the greatest proportion in both medium and large firms with 27.88% and 20.73% respectively. Table 3.3 displays the proportion of survey responses based on firms' technology intensity and size. The surveyed firms are dominated by low technology industries (73.45%), and high-technology industries only accounted for 0.93%. The same patterns were also found for both medium and large firms.

Table 3.1 Distribution of sample and population firms by industry in 2010 (%)

ISIC Rev 3	Manufacture Sectors[1]	Sample (1,179 firms)	Population[2] (23,345 firms)
Division 15	Food & beverages	26.21	23.90
Division 16	Tobacco products	5.00	4.19
Division 17	Textiles	10.69	11.07
Division 18	Wearing apparel; dressing and dyeing of fur	8.99	8.43
Division 19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness & footwear	2.97	2.84
Division 20	Wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	5.00	5.30
Division 21	Paper and paper products	1.78	2.16
Division 22	Printing and publishing	3.39	1.98
Division 23	Coke, refined petroleum products, & nuclear fuel	0.08	0.32
Division 24	Chemicals & chemical products	3.50	4.64
Division 25	Rubber & plastics products	5.34	7.11
Division 26	Other non-metallic mineral products	8.31	6.92
Division 27	Basic metals	0.51	1.10
Division 28	Fabricated metal products, except machinery and equipment	3.14	3.85
Division 29	Machinery & equipment n.e.c	1.27	1.72
Division 30	Office, accounting & computing machinery	0.08	0.04
Division 31	Electrical machinery & apparatus n.e.c	0.93	1.05
Division 32	Radio, TV & communication equipment & apparatus	0.68	0.94
Division 33	Medical, precision & optical instruments, watches and clocks	0.17	0.29
Division 34	Motor vehicles, trailers & semi-trailers	1.19	1.19
Division 35	Other transport equipment	1.27	1.40
Division 36	Furniture; manufacturing n.e.c.	8.99	9.39
Division 37	Recycling	0.45	0.17

Source: [1]http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=17;
[2]http://www.bps.go.id/linkTableDinamis/view/id/896

Table 3.2 Industry composition by size

Sectors	% (Frequency)		
	Medium	Large	Total
ISIC 15	27.88 (252)	20.73 (57)	26.21 (309)
ISIC 16	4.98 (45)	5.09 (14)	5.00 (59)
ISIC 17	10.18 (92)	12.36 (34)	10.69 (126)
ISIC 18	9.07 (82)	8.73 (24)	8.99 (106)
ISIC 19	3.32 (30)	1.82 (5)	2.97 (35)
ISIC 20	4.76 (43)	5.82 (16)	5.00 (59)
ISIC 21	1.33 (12)	3.27 (9)	1.78 (21)
ISIC 22	3.76 (34)	2.18 (6)	3.39 (40)
ISIC 23	0.00 (0)	0.36 (1)	0.08 (1)
ISIC 24	2.88 (26)	5.82 (16)	3.5 (42)
ISIC 25	4.42 (40)	8.36 (23)	5.34 (63)
ISIC 26	9.62 (87)	4.00 (11)	8.31 (98)
ISIC 27	0.33 (3)	1.09 (3)	0.51 (6)
ISIC 28	3.10 (28)	3.27 (9)	3.14 (37)
ISIC 29	1.22 (11)	1.45 (4)	1.27 (15)
ISIC 30	0.11 (1)	0.00 (0)	0.08 (1)
ISIC 31	0.55 (5)	2.18 (6)	0.93 (11)
ISIC 32	0.33 (3)	1.82 (5)	0.68 (8)
ISIC 33	0.11 (1)	0.36 (1)	0.17 (2)
ISIC 34	1.00 (9)	1.82 (5)	1.19 (14)
ISIC 35	1.00 (9)	2.18 (6)	1.27 (15)
ISIC 36	9.62 (87)	6.91 (19)	8.99 (106)
ISIC 37	0.44 (4)	0.36 (1)	0.42 (5)
Total	100 (904)	100 (275)	100 (1.179)

Table 3.3 Survey responses by technology intensity and size

Technology intensity	Medium	Large	Total
Low-tech (ISIC 15-22, 36-37)	75.33 (681)	67.27 (185)	73.45 (866)
Medium-low tech (ISIC 23, 25-28)	17.48 (158)	17.09 (47)	17.39 (205)
Medium-high tech (ISIC 24, 29, 31, 34 & 35)	6.64 (60)	13.45 (37)	8.23 (97)
High-tech (ISIC 30, 32, 33)	0.55 (5)	2.18 (6)	0.93 (11)
Total	100 (904)	100 (275)	100 (1,179)

To differentiate how Indonesian manufacturing firms source knowledge from different sources, various sources of knowledge are classified into three main categories: *R&D activities* (internal and external R&D), *informal knowledge* (market/commercials, science institutions, associations, and open sources) and *formal cooperation* (firm group, market/commercials, science-institutions, and associations). Table 3.4 presents the classification of the three groups of knowledge derived from the IIS 2011.

Table 3.4 Sources of knowledge classification

R&D ACTIVITIES	INFORMAL NETWORKS	FORMAL COOPERATION
Internal R&D External R&D	Market/commercials *e.g. suppliers, customers, competitors, consultants, commercial labs*	Firms' group *Cooperation partners: firms within enterprise group*
	Science-institutions *e.g. universities, polytechnic, gov. R&D, non-profit R&D*	Market/commercials *Cooperation partners: suppliers, competitors, consultants, commercial labs*
	Associations *e.g. industry associations, investors, entrepreneurs,*	Science-institutions *Cooperation partners: universities, gov. R&D*
	Open sources *e.g. events, science publication, internet*	Associations *Cooperation partners: industry associations*

The IIS 2011 questionnaire provides slightly different sources of information compared to innovation survey questionnaires used in developed countries like the CIS that is frequently used by European countries. For example, sources from polytechnic, investors, experienced entrepreneurs and the internet are included in the IIS 2011. Therefore, it is expected that this study will provide different insights from existing innovation process studies that focus on particular sources of knowledge that include internal R&D (e.g. Crepon et al., 1998; Lööf and Heshmati, 2002), external R&D, the market and public research institutes (Ganotakis and Love, 2012; Roper et al., 2008).

3.3.2. Methods

3.3.2.1. Knowledge sourcing activity

In this stage, the main issue that is addressed is the behaviour of Indonesian manufacturing firms in sourcing knowledge from various sources. More specifically, synergistic or substitution relationships among the three groups of knowledge are tested. According to Roper et al., (2008), to estimate the simultaneous knowledge sourcing equations (see the equation 1), multivariate probit (MVP) would be the most efficient approach. However, the efficiency gains from MVP are reduced where the vectors of independent variable are strongly correlated (Greene, 2005). Beside the issue of similarity of independent variables, the following are difficulties that also arise when adopting MVP practically in using survey-based data (Roper et al., 2008). *First,* any gains in statistical efficiency by using the simultaneous estimation approach will be offset due to a larger number of missing values. *Second,* in practice, achieving convergence with an MVP estimator places some limits on the degree of simultaneity which it is possible to include. However, it is

undesirable because what is of interest here is the complementary or substitute relationship between knowledge sourcing activities. *Third,* to derive marginal effects, the usage of simpler modelling frameworks are more straightforward than MVP and this is important to gain a better understanding of the innovation value chain.

Therefore, following Roper et al., (2008), a simple approach of single equation probit model is used to test Hypothesis 1 with the dependent variables being a series of sources of knowledge. This allows for a detailed analysis of the impact of 17 various knowledge sources. Although the approach sacrificing some statistical efficiency, however it provides "substantial gains in terms of the number of observations used, ability to reflect more fully the relationship between knowledge sourcing activities, and ability to identify readily interpretable marginal effects" (Roper at al., 2008, p. 963). The following is the function of the probability that a firm engages in each of the 17 knowledge sourcing activities.

$$KS^{*}_{jit} = \beta' KS_{kit} + \gamma' RI_{jit} + \varepsilon_{jit}$$
$$KS_{jit} = 1 \text{ if } KS^{*}_{jit} > 0;\ KS_{jit} = 0 \text{ otherwise} \qquad (1)$$

Where, KS_{jit} stands for the i^{th} firm's knowledge sourcing activity j (or k) at time t, and $j, k = 1, 2, 3….17$, $i = 1,……, n;\ t=1,…..,T$. The error term ε_{jit} is assumed to follow a multivariate normal distribution with mean zero and variance-covariance matrix V, where V has values of 1 on the leading diagonal and $\rho_{jk} = \rho_{kj}$ for $j \neq k$. KS_{kit} represents the firm's other knowledge sourcing activities. If β is positive, this would suggest a complementary relationship between the knowledge sourcing activities; negative β would suggest a substitute relationship. RI_{jit} is a set of indicators of the firm's resource (table 3.5 displays the list of the firm's resource).

3.3.2.2. Knowledge transformation activity

In the second IVC link, an innovation or knowledge production function is used to model the knowledge transformation activities (e.g. Geroski, 1990; Harris and Trainor, 1995). Logit regression is used to test Hypotheses 2 with the dependent variables being different types of innovation. Tobit regression is employed when the dependent variable is innovation success (i.e. the proportion of sales derived from product innovation new to the market) that has both upper and lower bounds (0 to 100%). In this study, the innovation or knowledge production function is as follows:

$$INNOV_i = \gamma_0 KS_i + \gamma_1 BREADTH + \gamma_2 INNBAR_i + \gamma_3 RES_i + \varepsilon_i \qquad (2)$$

Where INNOV is an innovation output indicator, KS represents knowledge sourcing activity, BREADTH represents the breadth of external knowledge use for innovation (Laursen and Salter, 2006), INNBAR is a set of innovation barriers and other variables have defined in the first equation. In this case, associations

between innovation and a set of explanatory variables such as knowledge, external knowledge breadth, innovation barriers and firm resources, are positive if $\gamma 0, \gamma 1, \gamma 2, \gamma 3 > 0$.

3.3.2.3. Knowledge exploitation activity

In the last link of the IVC, OLS regression is used to test Hypothesis 3, and the dependent variable is the firms' productivity, which is a measure of how innovation affects overall firm performance. The equation of the knowledge exploitation activity is as follows:

$$PERFORM_i = x_0 INNOV_i + xi RES_i + \varepsilon_i \qquad (3)$$

Where PERFORM is an indicator of firm performance, INNOV is innovation indicators that consist of product, process, organisation, and marketing innovation. In this case, the association between firm performance and a range of innovation output is positive if $x0 > 0$.

3.4. Results

3.4.1. Descriptive statistics

Table 3.5 presents descriptive statistics for the IIS 2011. Following the 3rd Oslo Manual, the IIS 2011 defines innovation as "the implementation of a new or significantly improved product (good or services), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD and Eurostat, 2005, p.46). Based on the definition that covers broad range of possible innovations, the IIS 2011 then defines an innovative firm as a firm that performed any product, process, organisational or marketing innovation from 2009 to 2010. According to Table 5, the mean of productivity (total sales/number of employees) is approximately IDR 1.3 trillion. The highest proportion is marketing innovation (42.8%), while the lowest is organisational innovation (31%). The mean of product innovations that are new to the market is lower than the same innovations that are new to the firm, and account for 28.8% versus 35.8% respectively. The mean of innovation success as the proportion of launched products new to the market accounted for 8.43%. The fact that marketing innovation outnumbered other innovation is typical in developing countries that tend to focus on the market rather than on the technology (Wamae, 2009).

Turning to knowledge sourcing activities, approximately 29% of firms report generating their own knowledge from internal R&D, while only 3.2% of firms source knowledge from external R&D. Firms report market/commercials as more important than other sources of knowledge, including suppliers, competitors and customers which represent 19.1%, 22.5% and 34.4%, respectively. These are followed by open sources (internet) and associations (entrepreneurs) that account for 11.3% and 14.6%, respectively. In

contrast, less than 5% of firms source science-based knowledge from universities, polytechnic, government and non-profit R&D institutions.

Regarding formal cooperation, less than 5% of firms cooperate with external agents. Nearly 4.8% of firms cooperate with suppliers and approximately 3% of firms cooperate with firms within the same group. Only a very small proportion of firms deal with cooperative partners such as consultants (1.7%), universities (1.3%) and competitors (1.2%), while other cooperative partners accounted for less than 1%. Among factors that hamper innovation activities, barriers related to financial resources are perceived to be more important than other barriers, accounting for 26% of factors that hamper innovation. Barriers related to employee and organisational behaviour, such as staff and manager resistance towards change, represent the lowest proportion of hampering factors, accounting for only 8%.

The mean of firm size as indicated by the number of employees is nearly 175 people. Of surveyed firms, mature firms (more than 20 years) dominate in the IIS 2011 data. The proportion of national firms is significantly higher at 90%, compared to multi-nationals and joint ventures, at 6% and 4.2%, respectively. Most of the surveyed firms operate in their headquarters, not in the manufacturing plants (91% versus 9.2%). Labour education levels are low. More than 50% of employees have no high school degree, which indicates the low level of education of the firms' human resources. In contrast, less than 5% of employees hold undergraduate degrees.

Table 3.5 Descriptive statistics

VARIABLES	Obs.	Mean	SD	Min.	Max.
Firm performance					
Productivity (total sales/number of employee)	1179	1312.096	8399.761	.088	125000
Innovation performance					
Innovation success (INNOVSUCCESS) *(% PRODINOV_NEW2MARKET sales)*	1179	8.43	16.99	0	100
Innovation output					
Product innovation (PRODINOV) (0/1)	1179	.377	.485	0	1
Product innovation new to the market (PRODINOV_NEW2MARKET) (0/1)	1179	.288	.453	0	1
Product innovation new to the firms (PRODINOV_NEW2FIRM) (0/1)	1179	.358	.480	0	1
Process innovation (PROCINOV) (0/1)	1179	.322	.468	0	1
Organisational innovation (ORGINOV) (0/1)	1179	.310	.463	0	1
Marketing innovation (MKTGINOV) (0/1)	1179	.428	.495	0	1
R&D Activities					
Internal R&D-R&D activities inside the firms (IN_RD) (0/1)	1179	.292	.455	0	1
External R&D-R&D activities outside the firms (EX_RD) (0/1)	1179	.032	.177	0	1
Market agents (highly important)					
Suppliers (SUPPLIERS) (0/1)	1179	.191	.393	0	1
Customers (CUSTOMERS) (0/1)	1188	.344	.475	0	1
Competitors (COMPETITORS) (0/1)	1179	.225	.418	0	1
Consultant (CONSULTANTS) (0/1)	1179	.041	.198	0	1
Commercial labs (COMMLAB) (0/1)	1179	.042	.200	0	1
Science institutions (highly important)					
University (UNIVERSITIES) (0/1)	1179	.031	.174	0	1
Polytechnic (POLTECH) (0/1)	1179	.027	.163	0	1
Government R&D institutions (GOV_RD) (0/1)	1179	.041	.198	0	1
Non-profit R&D institutions (NONPROF_RD) (0/1)	1179	.036	.185	0	1
Associations (highly important)					
Investors (INVESTORS) (0/1)	1179	.091	.287	0	1
Industry Association (IND_ASSOC) (0/1)	1179	.065	.247	0	1
Entrepreneurs (ENTREPRENEURS) (0/1)	1179	.146	.353	0	1

Open sources (highly important)					
Events (EVENTS) (0/1)	1188	.109	.312	0	1
Science Publication (SCIENCE_PUB) (0/1)	1188	.067	.251	0	1
Internet (INTERNET) (0/1)	1179	.113	.316	0	1
Formal cooperation					
Cooperation within firms' groups (COOP_GROUP) (0/1)	1179	.026	.160	0	1
Cooperation with suppliers (COOP_SUPP) (0/1)	1179	.048	.215	0	1
Cooperation with competitors (COOP_COMPET) (0/1)	1179	.012	.108	0	1
Cooperation with consultants (COOP_CONSUL) (0/1)	1179	.017	.129	0	1
Cooperation with commercial labs (COOP_COMMLAB) (0/1)	1179	.004	.065	0	1
Cooperation with universities (COOP_UNIV) (0/1)	1179	.013	.112	0	1
Cooperation with government R&D (COOP_GOVRD) (0/1)	1179	.008	.087	0	1
Cooperation with industry association (COOP_ASSOC) (0/1)	1179	.008	.087	0	1
Financial barriers (highly relevant)					
Lack of internal funding (INBAR_INFUND) (0/1)	1196	.268	.443	0	1
Lack of external funding (INBAR_EXFUND) (0/1)	1196	.262	.440	0	1
High costs too high (INBAR_COST) (0/1)	1196	.268	.443	0	1
Excessive risks (INBAR_RISK) (0/1)	1196	.268	.443	0	1
Knowledge barriers (highly relevant)					
Staff resistance (INBAR_STAFF) (0/1)	1196	.130	.337	0	1
Manager resistance (INBAR_MGR) (0/1)	1196	.078	.268	0	1
Organisational rigidities (INBAR_ORGRIGID) (0/1)	1196	.077	.267	0	1
Lack of qualified personnel (INBAR_PERSON) (0/1)	1196	.176	.381	0	1
Lack of information on technology (INBAR_TECH) (0/1)	1196	.160	.366	0	1
Lack of information on markets (INBAR_MARKET) (0/1)	1196	.130	.336	0	1
Lack of ability to find cooperation (INBAR_COOP) (0/1)	1196	.209	.407	0	1
Inability to allocate labour (INBAR_LABOUR) (0/1)	1196	.145	.352	0	1
Market barriers (highly relevant)					
Market dominated by foreign firms (INBAR_DOM) (0/1)	1196	.218	.413	0	1
Uncertain demand for inn. Products (INBAR_UNCER) (0/1)	1196	.177	.382	0	1
Lack of customer acceptance (INBAR_CUSTOM) (0/1)	1196	.120	.326	0	1
Institutions barriers (highly relevant)					
Lack of sufficient infrastructure (INBAR_INFRA) (0/1)	1196	.156	.363	0	1
Lack of industry standard (INBAR_STANDARD) (0/1)	1196	.135	.342	0	1

Lack of regulation from gov. (INBAR_REG) (0/1)	1196	.138	.345	0	1
Firms Resources					
Size (number of employee)	1179	174.608	1318.078	20	32977
Firms' age (years)	1179	21.077	12.704	0	84
Export (%)	1179	9.726	25.106	0	100
Ownership National (OWN_NATIONAL)	1179	0.899	0.301	0	1
Ownership Multi National (OWN_MULTI)	1179	0.059	0.235	0	1
Ownership Joint Venture (OWN_JOINT)	1179	0.042	0.202	0	1
Operation Plant (OPS_PLANT)	1179	0.092	0.289	0	1
Operation Head Quarter (OPS_HQ)	1179	0.908	0.289	0	1
Education Under High school (EDU_UNDERHS) (%)	1179	56.247	36.423	0	100
Education High School (EDU_HS) (%)	1179	36.430	31.492	0	100
Education Diploma (EDU_DIPLOMA) (%)	1179	3.246	6.779	0	55
Education Under Graduate (EDU_UNDERGRAD) (%)	1179	4.077	8.623	0	90
Employees' proportion in R&D dept. (RD_STAFF) (%)	1179	2.986	6.717	0	57
Low technology (LOW_TECH) (0/1)	1179	.735	.442	0	1
Medium-low technology (MEDLOW_TECH) (0/1)	1179	.174	.379	0	1
Medium-high technology (MEDHIGH_TECH) (0/1)	1179	.082	.275	0	1
High technology (HIGH_TECH) (0/1)	1179	.009	.096	0	1

Appendixes 3.1 and 3.2 present correlation output of the types of innovation, innovation success and sources of knowledge variables. Apart from correlation analysis, variance inflation factors (VIF) are tested to check multi-collinearity among investigated variables. Outputs of mean VIF are presented in Tables 3.6 to 3.9. It can be observed that all the mean VIF values are less than 5, which means that there is no indication of multi-collinearity among the variables.

3.4.2. Knowledge sourcing activity

Tables 3.6 and 3.7 present a series of probit regressions of equation (1) that represents the knowledge sourcing activity of Indonesian manufacturing firms. In this section, discussion is divided based on different sources of knowledge, including R&D activities, informal knowledge and formal cooperation, to provide an understanding of how knowledge is sourced differently.

3.4.2.1. R&D activities

Table 3.6 indicates a synergistic relationship between internal and external R&D and this in in line with previous findings (e.g. Cassiman and Veugelers, 2006; Ganotakis and Love, 2012; Schmiedeberg, 2008; Veugelers and Cassiman, 1999). Firms are more likely to perform external R&D (EX_RD) if they also generate their own knowledge from internal R&D (IN_RD). The same relationship also exists between IN_RD and external agents from market/commercials (CUSTOMERS, COMPETITORS and COMM_LAB) and from associations (ASSOCIATIONS and ENTREPRENEURS). However, the firms interact less with external networks from science institutions and open sources. Firms also interact less with external actors if they already perform EX_RD. Based on this finding, the first hypothesis is supported.

3.4.2.2. Informal knowledge

Turning to informal knowledge (see Table 3.6), it can be observed that firms that source knowledge from market/commercials tend to interact with other market/commercials networks, associations and open sources. However, these firms interact less with scientific institutions, with the exception that firms sourcing knowledge from COMM_LABS tend to interact with UNIVERSITIES and GOV_RD. Firms that source knowledge from SUPPLIERS and COMPETITORS are more likely to source from ASSOCIATIONS. In addition, firms tend to source knowledge from open sources if they already source from CUSTOMERS. To sum up, in the market/commercials groups, synergistic relationships tend to exist among market/commercials; between market/commercials and associations; and between market/commercials and open sources networks.

In relation to scientific institutions, a synergistic relationship can also be identified among the institutions and between the institutions and associations. However, there are few negative and significant

associations, and these are shown only between POLTECH and INVESTORS and between UNIVERSITIES and SCIENCE_PUB. This may indicate that firms that already source knowledge from POLTECH tend not to interact with INVESTORS, while firms that source knowledge from UNIVERSITIES tend to cite knowledge from SCIENCE_PUB. Lastly, firms that source knowledge from associations and open source networks are more likely to interact with all external knowledge networks proportionally.

Turning to control variables, exporters tend to rely on knowledge that is sourced from SUPPLIERS and ENTREPRENEURS. Both national and multi-national firms are similar in that they have positive and significant associations with ENTREPRENEURS. In contrast, both national and multi-national firms have negative and significant associations with INVESTORS and the INTERNET. It is striking that HIGH_TECH firms do not have positive associations with R&D activities. A speculative reason for this phenomenon is that these firms tend to import advanced technology from advanced countries as shown in Thee's (2005) study. However, it is important to note that all the coefficient values among firm resources and a wide range of sources of knowledge tend to show weak relationships.

Table 3.6. Knowledge sourcing activity - (IV: R&D and informal knowledge)

INDEPENDENT VARIABLES	Model 1 IN_RD	Model 2 EXT_RD	Model 3 SUPPLIER	Model 4 CUSTOM	Model 5 COMPET	Model 6 CONSUL	Model 7 COMMLAB	Model 8 UNIVERSITY	Model 9 POLTECH
INTERNAL_RD	-	**.088*******(.017)**	-.021 (.029)	**.059******(.026)**	**.045******(.023)**	.018 (.011)	**.023******(.011)**	**.019******(.009)**	.006 (.008)
EXTERNAL_RD[2]	**.568*******(.098)**	-	.012 (.065)	-.032 (.060)	.021 (.051)	-.002 (.021)	.019 (.020)	-.003 (.016)	.010 (.013)
Market/Commercials									
SUPPLIERS	-.023 (.030)	.006 (.013)	-	.031 (.028)	-.005 (.026)	-.008 (.014)	**.025******(.012)**	-.003 (.011)	.005 (.009)
CUSTOMERS	**.077*******(.028)**	-.006 (.012)	.041 (.029)	-	**.287*******(.018)**	**-.023*****(.014)**	.000 (.013)	.006 (.010)	-.003 (.009)
COMPETITORS	.044 (.030)	.005 (.011)	-.004 (.032)	**.329*******(.022)**	-	**.031*******(.012)**	.016 (.012)	-.003 (.010)	.006 (.008)
CONSULTANT	.081 (.063)	-.003 (.019)	-.043 (.066)	**-.158******(.063)**	**.109******(.047)**	-	**.072*******(.016)**	.008 (.014)	.008 (.012)
COMMLAB	.085 (.063)	.031 (.019)	**.121*****(.062)**	-.017(.066)	.050 (.051)	**.069*******(.016)**	-	**.042*****(.013)	-.005 (.012)
Science									
UNIVERSITIES	**.176******(.076)**	-.027 (.026)	.0004 (.077)	.023 (.077)	-.075 (.063)	.020 (.020)	**.065***(.019)**	-	**.042***(.011)**
POLYTECHNIC	-.036 (.083)	.015 (.025)	.046 (.084)	-.134 (.085)	.018 (.062)	-.003 (.023)	-.016 (.024)	**.047***(.015)**	-
GOV_RD	-.013 (.071)	**-.051*(.029)**	-.014 (.078)	-.038 (.073)	-.025 (.057)	.001 (.021)	**.036*(.021)**	**.024*(.013)**	**.037***(.011)**
NON_PROFITRD	-.012 (.072)	**.048******(.023)**	-.034 (.077)	**.224***(.078)**	-.037 (.055)	.030 (.020)	.021 (.020)	.012 (.013)	**.019*(.010)**
Associations									
INVESTORS	.033 (.045)	**.024*(.014)**	.017 (.045)	.045 (.045)	.031 (.035)	.013 (.014)	-.001 (.015)	**.019*(.011)**	-.015 (.011)
IND_ASSOC.	.051 (.050)	-.011 (.017)	-.043 (.053)	.031 (.054)	.007 (.041)	**.030**(.015)**	.004 (.016)	**.025**(.011)**	.006 (.010)
ENTREPRENEURS	**.176*******(.037)**	-.006 (.013)	-.021 (.040)	**.125***(.036)**	**.064**(.030)**	.003 (.014)	.012 (.014)	-.010 (.012)	.010 (.009)
Open sources									
EVENTS	-.003 (.043)	.004 (.015)	.041 (.043)	**.177***(.044)**	**.064**(.033)**	.001 (.015)	-.005 (.015)	.009 (.011)	-.002 (.009)
SCIENCE_PUB	-.026 (.053)	.0003 (.017)	-.060 (.053)	**.215***(.061)**	.039 (.039)	.018 (.016)	**.033**(.015)**	-.014 (.013)	**.029***(.010)**
INTERNET	**.229*******(.037)**	.011 (.012)	.050 (.040)	**.177***(.037)**	-.048 (.031)	**.029**(.013)**	-.022 (.015)	-.004 (.011)	.009 (.008)
Firm resources									
SIZE	-.0002(.0003)	-.0003(.0003)	.0002(.0001)	-.0001(.0001)	-.0003(.0003)	-.0003(.0004)	-.0003(.0002)	-.0001(.0002)	-.0002(.0003)
AGE	-.00006(.001)	-.0003(.0004)	.001(.001)	.001(.001)	.0001(.001)	.0003(.0004)	-.001(.0005)	-.001(.0004)	.0002 (.0003)
EXPORT	-.0003(.0005)	.00002(.0002)	**.001**(.0004)**	.0004(.0004)	-.0001(.0004)	.0002(.0002)	.0002(.0002)	-.0003(.0002)	.00003(.0001)

[2] External R&D in this study is grouped in R&D activities along with internal R&D, however, based on the degree of externalisation, external R&D, informal and open networks, and cooperation activities 'are external to the enterprise to various degrees, depending on their ownership and the contractual structures of the relationship between our enterprise and the other party or parties to the transfer' (Frenz and Ietto-Gillies, 2009, p. 1126).

OWN_NATIONAL	.098(.064)	.007(.030)	.034(.059)	-.029(.057)	-.003(.051)	.013(.030)	.042(.033)	-.002(.021)	.014(.024)
OWN_MULTI	.123(.077)	-.0002(.037)	.102(.072)	-.005(.071)	-.067(.068)	.017(.036)	-	.014(.024)	.004 .029)
OWN_JOIN	-	-	-	-	-	-	-	-	-
OPS_PLANT	-.002 (.043)	-.020 (.022)	.016 (.041)	-.031 (.040)	-.013 (.038)	-.001 (.019)	-.027 (.027)	.009 (.013)	.012 (.011)
OPS_HEAD	-	-	-	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-	-	-	-
MEDLOW_TECH	-.071 (.029)	.012 (.016)	.032 (.031)	.027 (.029)	-.032 (.027)	.025 (.016)	.007 (.014)	**-.024*** (.008)**	.010 (.012)
MEDHIGH_TECH	.004 (.044)	**-.025** (.010)**	.005 (.042)	.036 (.041)	-.036 (.037)	-.006 (.017)	.014 (.023)	-.001 (.015)	.008 (.016)
HIGH_TECH	-.049 (.109)	-	-.045 (.095)	.188 (.137)	-.095 (.082)	-	-	.002 (.037)	-
EDU_UNDERHS	-.0003 (.001)	-.001 (.001)	-.0004 (.001)	-.0005 (.001)	-.001 (.001)	-.001 (.001)	.001(.001)	-.0002(.0005)	.001(.001)
EDU_HIGHSCHOOL	-.0004 (.002)	-.001 (.001)	.001 (.001)	-.0002 (.001)	-.001 (.001)	-.001 (.001)	.001(.001)	-.0003(.001)	.0005(.001)
EDU_DIPLOMA	-.001 (.003)	-.0004 (.001)	.001 (.003)	.001 (.003)	.000 (.002)	.000 (.001)	.001(.001)	-.0002(.001)	.0004(.001)
EDU_UNDERGRAD	-	-	-	-	-	-	-	-	-
RD_STAFF	.0001 (.002)	**-.002*(.001)**	**.006***(.002)**	-.002 (.002)	.000 (.002)	.000 (.001)	.000 (.001)	-.0002 (.001)	.000 (.001)
Observation	1,179	1,168	1,179	1,179	1,179	1,168	1,119	1,179	1,168
LR chi2(29)	297.2	98.16	53.52	498.23	352.76	136.41	154.75	154.13	162.17
Prob > chi2	.000	.000	.0037	.000	.000	.000	.000	.000	.000
Pseudo R2	.209	.293	.047	.327	.281	.341	.385	.469	.553
Log likelihood	-563.198	-118.462	-547.930	-511.940	-451.881	-132.001	-123.827	-87.424	-65.588
Mean VIF	2.76	2.77	2.78	2.74	2.75	2.76	2.76	2.75	2.75

*Notes: Significant levels *p≤10, **p≤05, ***p≤001. All figures in the tables are marginal effects generated from probit models.*

Table 3.6. Knowledge sourcing activity - (IV: R&D and informal knowledge) *(continued)*

INDEPENDENT VARIABLES	Model 10 GOV_RD	Model 11 NPROFIT_RD	Model 12 INVESTOR	Model 13 TRADE_ASSOC	Model 14 ENTREPRENEUR	Model 15 EVENTS	Model 16 SCIENCE_PUB	Model 17 INTERNET
INTERNAL_RD	.004 (.009)	.001 (.010)	.025 (.015)	**.030**(.013)**	**.087***(.016)**	.010 (.016)	.003 (.013)	**.112***(.016)**
EXTERNAL_RD	-.022 (.018)	**.030*(.017)**	**.048*(.028)**	-.011 (.025)	-.020 (.035)	.014 (.031)	.010 (.025)	.030 (.032)
Market/commercials								
SUPPLIERS	-.001 (.011)	-.007 (.012)	.004 (.017)	-.009 (.015)	-.014 (.020)	.017 (.018)	-.020 (.015)	.025 (.020)
CUSTOMERS	.002 (.010)	**.041***(.013)**	**.037**(.017)**	.013 (.015)	**.084***(.018)**	**.078***(.018)**	**.071***(.016)**	**.087***(.018)**
COMPETITORS	-.003 (.009)	-.010 (.010)	.016 (.016)	**.024*(.014)**	**.047***(.017)**	**.039**(.016)**	.019 (.013)	-.009 (.018)
CONSULTANT	-.000004 (.015)	.008 (.017)	.012 (.028)	**.042**(.021)**	.020 (.035)	-.003 (.031)	.019 (.022)	**.080**(.033)**
COMMLAB	**.023*(.014)**	.010 (.015)	-.009 (.028)	-.012 (.023)	.045 (.033)	-.005 (.030)	**.048**(.021)**	-.039 (.037)
Science institutions								
UNIVERSITIES	**.023*(.013)**	.013 (.015)	**.065**(.032)**	**.045*(.024)**	-.030 (.042)	.029 (.035)	**-.045*(.027)**	-.019 (.040)
POLYTECHNIC	**.050***(.015)**	.019 (.016)	**-.105**(.042)**	.001 (.027)	**.079*(.044)**	-.031 (.036)	**.081***(.024)**	.044 (.041)
GOV_RD	-	**.071***(.015)**	**.130***(.030)**	.032 (.022)	-.036 (.038)	.046 (.031)	.000 (.024)	.055 (.038)
NON_PROFITRD	**.061***(.012)**	-	.009 (.024)	**.036**(.017)**	-.029 (.028)	-.005 (.022)	.015 (.017)	-.028 (.029)
Associations								
INVESTORS	**.043***(.011)**	-.001 (.013)	-	**.046***(.015)**	**.164***(.021)**	**.058**(.023)**	.024 (.017)	.013 (.023)
IND_ASSOC.	.013 (.010)	**.022*(.012)**	**.058***(.021)**	-	**.085***(.020)**	**.077***(.018)**	-.017 (.016)	**.072***(.020)**
ENTREPRENEURS	-.010 (.011)	-.001 (.012)	**.123***(.017)**	.018 (.015)	-	.009 (.030)	.029 (.021)	-.062 (.040)
Open sources								
EVENTS	.016 (.010)	.002 (.012)	-.018 (.031)	.026 (.022)	-.010 (.039)	-	**.096***(.013)**	.033 (.023)
SCIENCE_PUB	-.0001 (.011)	**.026**(.012)**	-.019 (.021)	**.036**(.015)**	**.099***(.022)**	**.145***(.019)**	-	**.057**(.025)**
INTERNET	**.019*(.010)**	-.015 (.013)	.008 (.018)	**.034**(.014)**	.039 (.027)	.030 (.019)	-.007 (.016)	-
Firm resources								
SIZE	.00001(.00003)	-.00001(.00003)	.00002(.00001)	-.00001(.00002)	-.00004(.00003)	.00002(.00001)	-.00002(.00001)	.00003(.00001)
AGE	-.0004 (.0004)	.0001 (.0004)	.0002(.001)	-.001(.0005)	.001(.001)	-.001(.001)	-.0002(.0005)	-.0004 (.001)
EXPORT	-.00003 (.0002)	-.0002 (.0002)	-.00001(.0003)	.0002(.0002)	**.001**(.0003)**	-.0003(.0003)	-.0002(.0002)	-.00001(.0003)
OWN_NATIONAL	.022(.025)	-.01 (.020)	**-.061**(.031)**	.033(.035)	**.105**(.048)**	-.047(.033)	.008(.029)	**-.067*(.035)**
OWN_MULTI	.003(.030)	.007(.025)	**-.078**(.042)**	**.069*(.039)**	**.105*(.056)**	-.030(.043)	-.009(.039)	-.054(.045)
OWN_JOIN	-	-	-	-	-	-	-	-

OPS_PLANT	-.016(.020)	.002(.017)	-.030(.027)	-.021(.024)	.042(.027)	-.008(.027)	.005(.021)	.005(.028)
OPS_HEAD	-	-	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-	-	-
MEDLOW_TECH	-.006(.011)	**.0100(.010)****	-.005(.018)	.002(.016)	.023(023)	-.026(.019)	-.011(.016)	.014(.022)
MEDHIGH_TECH	.001(.015)	-	.018 (.029)	**.048(.028)***	-.0003(.029)	-.027)	.027(.025)	.027(.031)
HIGH_TECH	.0111(.103)	-.005(.034)	-.055 (.037)	.049(.076)	.015(.072)	.082 (.090)	-	-.038(.061)
EDU_UNDERHS	-.0004(.0004)	.001(.001)	-.001(.001)	.001(.001)	-.0001(.001)	.002(.001)	-.001(.001)	.000(.001)
EDU_HIGHSCHOOL	-.0004(.0005)	.001(.001)	-.001(.001)	.002(.001)	.0003 (.001)	.002 (.001)	**-.001*(.001)**	.000(.001)
EDU_DIPLOMA	-.0003(.001)	.002(.001)	-.0001(.002)	.001(.002)	-.002 (.002)	.002 (.002)	-.001 (.001)	.000(.002)
EDU_UNDERGRAD	-	-	-	-	-	-	-	-
RD_STAFF	-.0004(.001)	.001(.001)	.001(.001)	.001(.001)	-.0004(.001)	.00 (.001)	.0002 (.001)	-.002(.001)
Observation	1179	1082	1179	1179	1179	1179	1168	1179
LR chi2(29)	226.89	172.32	249.06	210.13	405.55	326.27	251.48	252.34
Prob > chi2	.000	.000	.000	.000	.000	.000	.000	.000
Pseudo R2	.565	.485	.347	.369	.414	.399	.431	.304
Log likelihood	-87.225	-91.467	-234.216	-179.467	-287.107	-246.055	-165.938	-289.245
Mean VIF	1.34	2.75	2.75	2.76	2.75	2.75	2.75	2.76

*Notes: Significant levels *p≤10, **p≤05, ***p≤001. All figures in the tables are marginal effects generated from probit models.*

3.4.2.3. Formal cooperation

Table 3.7 displays how the firms source knowledge from formal cooperation. It can be observed that firms that cooperate with other firms in the same group (COOP_GROUP) and suppliers (COOP_SUPP) are more likely to generate knowledge from internal (IN_RD) and external R&D (EX_RD). These firms also tend to source knowledge from non-scientific institutions. It may be speculated that generating and sourcing knowledge from R&D activities does not lead firms to cooperate with external scientific institutions. Meanwhile, firms that are involved in formal cooperation with other networks within market/commercials, including competitors, consultants and commercial labs are more likely interact informally with market/commercials but tend to interact less with other external knowledge agents. Lastly, firms that collaborate with public R&D and industry associations tend to interact less with other external agents.

Turning to firm resources, firms' sizes and ages have no positive and significant association to any external networks. Exporters tend to source knowledge from CONSULTANT, COMMLAB, and ENTREPRENEUR. None of the multi-national and or joint venture firms have significant and positive associations with any different sources of knowledge. While, national firms are negatively and significantly associated to open sources of knowledge such as EVENT and INTERNET. Firms that operated in plants factories are more likely not to source knowledge from GOV_RD and IND_ASSOC. Surprisingly, when HIGH_TECH firms perform cooperation, they tend not to not interact with any external networks. While MEDLOW_TECH firms have negative and significant associations with external agents from science institutions and events. However, all significant coefficients between control variables and sources of knowledge show weak relationships.

Table 3.7. Knowledge sourcing activity – (IV: Formal knowledge)

INDEPENDENT VARIABLES	Model 1 INT_R&D	Model 2 EXT_RD	Model 3 SUPPLIER	Model 4 CUSTOMER	Model 5 COMPET	Model 6 CONSUL	Model 7 COMMLAB	Model 8 UNIVERSITY
COOP_GROUP	**.519*****(.132)	**.056*****(.016)	.087 (.078)	**.230****(.103)	.105 (.085)	.015 (.035)	**.088*****(.031)	.044 (.031)
COOP_SUPPLIER	**.266*****(.075)	**.078*****(.014)	**.206*****(.059)	.114 (.079)	.063 (.067)	.020 (.026)	.022 (.027)	-.003 (.029)
COOP_COMPET	.282 (.199)	-.014 (.022)	.016 (.113)	.146 (.154)	**.211*(**.127)	-.035 (.059)	-.073 (.065)	-
COOP_CONSUL	.006 (.151)	-.015 (.022)	-.115 (.117)	-.151 (.139)	-.121 (.119)	**.075*(**.040)	**-.092***(.055)	**-.120***(.066)
COOP_COMMLAB	-.604 (.763)	-.002 (.047)	.328 (.202)	-.052 (.219)	**.354*(**.206)	**.152****(**.063)	.094 (.064)	.066 (.059)
COOP_UNIV	.117 (.157)	.019 (.025)	**-.666****(.289)	-.009 (.157)	-.022 (.137)	.061 (.042)	.056 (.046)	**.134*****(.038)
COOP_GOVRD	-	.032 (.027)	**.345***(.198)	-.013 (.191)	.112 (.161)	.007 (.063)	.072 (.063)	.0004 (.054)
COOP_IND-ASSOC	**.383***(.203)	.012 (.031)	.122 (.134)	.001 (.169)	.172 (.141)	-	.075 (.049)	.021 (.060)
Firm resources								
SIZE	-.00005 (.00004)	-.00002 (.00003)	-.0001 (.00004)	-1.4E-05 (.00001)	.000 (.000)	-.00005 (.00005)	-.00002 (.00003)	-6.18E-06 (2.05E-5)
AGE	.0007 (.001)	.00001 (.0004)	.001 (.001)	.001 (.001)	.001 (.001)	.00004 (.0004)	-.0001 (.0005)	-.0002 (.0004)
EXPORT	-.00004 (.001)	-.0001 (.0002)	.00001 (.0004)	.001 (.001)	.000 (.000)	**.0003*(**.0002)	**.0003***(.0002)	-.0002 (.0002)
OWN_NAT	.080 (.070)	.001 (.022)	.044 (.061)	-.081 (.070)	-.023 (.061)	.086 (.075)	.027 (.032)	-.011 (.024)
OWN_MULTI	.109 (.086)	-.019 (.033)	.044 (.075)	-.063 (.089)	-.063 (.080)	.087 (.078)	-	.008 (.029)
OWN_JOIN	-	-	-	-	-	-	-	-
OPS_PLANT	-.016 (.047)	-.012 (.019)	.055 (.040)	-.066 (.051)	-.050 (.045)	-.011 (.023)	-.032 (.029)	-.013 (.019)
OPS_HQ	-	-	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-	-	-
MEDLOW_TECH	**-.078 (.032)****	-.003 (.011)	.037 (.032)	-.014 (.037)	-.047 (.031)	.006 (.015)	-.005 (.015)	**-.025 (.010)*****
MEDHIGH_TECH	.016 (.049)	**-.023 (.012)***	.011 (.042)	.039 (.053)	-.024 (.045)	-.004 (.020)	.011 (.026)	-.010 (.017)
HIGH_TECH	-.001 (.134)	-	-.040 (.098)	.197 (.152)	-.051 (118)	-	-	.062 (.086)
EDU_UNDERHS	-.0005 (.002)	-.0002 (.001)	-.001 (.001)	-.002 (.002)	-.002 (.001)	-.00004 (.001)	.001 (.001)	-.0001 (.001)
EDU_HIGHSCHOOL	-.001 (.002)	-.0001 (.001)	-.001 (.001)	-.001 (.002)	-.002 (.002)	-.0002 (.001)	.000 (.001)	-.0005 (.001)
EDU_DIPLOMA	-.002 (.003)	-.0003 (.001)	-.003 (.003)	-.002 (.003)	-.002 (.003)	.001 (.001)	.001 (.001)	.0002 (.001)
EDU_UNDERGRAD	-	-	-	-	-	-	-	-
STAFF_RD	-.001 (.002)	-.001 (.001)	-.0005 (.002)	-.0005 (.002)	.001 (.002)	.001 (.001)	**.001***(.001)	.000579 (.0007)
Observation	1170	1168	1179	1179	1179	1159	1119	1165
LR chi2(49)	98.56	119.68	41.76	24.98	33.9	50.58	40.72	39.71

Prob > chi2	.000	.000	.0067	.2982	.0503	.0002	.004	.0081
Pseudo R2	.070	.357	.036	.016	.027	.127	.101	.121
Log likelihood	-651.35	-107.70	-553.81	-748.57	-611.31	-174.54	-180.84	-144.184
Mean VIF	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28

*Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.*

Table 3.7. Knowledge sourcing activity – (IV: Formal knowledge) *continued*

INDEPENDENT VARIABLES	Model 9 POLTECH	Model 10 GOV_RD	Model 11 NPROFIT_RD	Model 12 INVESTOR	Model 13 IND_ASSOC	Model 14 ENTREP	Model 15 EVENTS	Model 16 SCI_PUB	Model 17 INTERNET
COOP_GROUP	.023 (.038)	.045 (.037)	.061 (.040)	.056 (.049)	.061 (.042)	**.129*(.063)**	**.104*(.057)**	**.115**(.046)**	.043 (.055)
COOP_SUPP	-.010 (.035)	-.007 (.032)	-.034 (.040)	**.069*(.039)**	.021 (.037)	**.119*(.050)**	.035 (.048)	.024 (.039)	**.110***(.042)**
COOP_COMPET	.072 (.055)	-	.104 (.067)	.027 (.071)	.066 (.063)	.061 (.094)	-.114 (.115)	-	-.090 (.088)
COOP_CONSUL	-	-.026 (.071)	-	-.053 (.067)	-.028 (.057)	-.023 (.085)	.047 (.077)	-.003 (.072)	.109 (.070)
COOP_COMMLAB	-	-	-	.040 (.112)	-	-.030 (.157)	-	-	**-.259*(.154)**
COOP_UNIV	-	.021 (.068)	**.101*(.058)**	.079 (.078)	.043 (.071)	.082 (.100)	**.152*(.087)**	-	.014 (.088)
COOP_GOVRD	-	**.121*(.071)**	-	.040 (.095)	.003 (.091)	.051 (.125)	-.0179 (.1298)	-	**.224**(.102)**
COOP_INDASSOC	-	-	-	.099 (.078)	**.107*(.064)**	-.051 (.118)	-.0364 (.1072)	.062 (.086)	.115 (.086)
Firm resources									
SIZE	-1.0E-05(.002)	-1.0E-06(1.0E-5)	-3.0E-06(.001)	.0001(.0001)	-.001(.0002)	-.0003(.004)	-.0002(.001)	-1.0E-05(.001)	-.001 (.001)
AGE	.0002 (.004)	-.0003 (.005)	.0004 (.005)	.001 (.001)	-.001 (.001)	.001 (.001)	.004 (.007)	.003 (.001)	.001 (.001)
EXPORT	.0001 (.002)	.0016 (.002)	-.0001 (.024)	.000 (.000)	.0004 (.000)	**.001**(.0004)**	.001 (.004)	.001 (.003)	.003 (.001)
OWN_NAT	-.006 (.026)	-.009 (.030)	-.040 (.026)	-.057 (.038)	-.001 (.041)	.049 (.057)	**-.074*(.042)**	-.029 (.036)	**-.068*(.041)**
OWN_MULTI	-.018 (.036)	-.017 (.040)	-.006 (.034)	-.056 (.051)	.043 (.047)	.053 (.069)	-.058 (.055)	-.051 (.049)	-.045 (.053)
OWN_JOIN	-	-	-	-	-	-	-	-	-
OPS_PLANT	-.014 (.020)	**-.060*(.034)**	-.036 (.027)	-.047 (.033)	**-.053*(.031)**	.013 (.036)	-.033 (.034)	-.017 (.028)	-.011 (.033)
OPS_HQ	-	-	-	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-	-	-	-
MEDLOW_TECH	-.005 (.012)	**-.025 (.012)****	**-.034 (.010)*****	-.016 (.021)	-.005 (.018)	.006 (.027)	**-.040 (.021)***	**-.031 (.017)***	.010 (.024)
MEDHIGH_TECH	-.004 (.019)	-.007 (.022)	-	.032 (.036)	.050 (.035)	.018 (.040)	-.027 (.032)	.014 (.032)	.038 (.038)
HIGH_TECH	-	.162 (.125)	.052 (.556)	.002 (.086)	.098 (.108)	.058 (.121)	.148 (.135)	-	.002 (.098)

EDU_UNDERHS	.0002 (.001)	-.0002 (.001)	.001 (.001)	-.001 (.001)	.005 (.001)	-.0001 (.001)	.001 (.001)	-.001 (.001)	.001 (.001)
EDU_HS	-.0002 (.001)	-.001 (.001)	.003 (.001)	-.002 (.001)	.006 (.001)	.0001 (.0014)	.001 (.001)	-.001 (.001)	.003 (.001)
EDU_DIPLOMA	-.0003 (.002)	-.004 (.001)	.001 (.002)	-.002 (.002)	-.005 (.0019)	-.002 (.003)	.001 (.002)	-.002 (.002)	-.002 (.002)
EDU_UNDERGRAD	-	-	-	-	-	-	-	-	-
STAFF_RD	.001 (.001)	.001 (.001)	.001 (.001)	.002 (.001)	.002 (.001)	.001 (.002)	.002 (.001)	.001 (.001)	-.001 (.002)
Observation	1132	1156	1053	1179	1174	1179	1174	1139	1179
LR chi2(49)	18.39	29.09	24.97	30.82	33.32	45.15	27.81	24.18	43.32
Prob > chi2	.302	.065	.095	.100	.043	.003	.146	.115	.004
Pseudo R2	.063	.073	.071	.043	.059	.046	.034	.042	.052
Log likelihood	-136.46	-185.16	-163.98	-343.34	-267.54	-467.31	-394.70	-277.51	-393.75
Mean VIF	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28

*Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.*

3.4.3. Knowledge transformation activity

Table 3.8 reports statistical outputs of logit regressions (models 1 to 6) and tobit regression (model 7) that represent the second link of the IVC and all results are expressed in marginal effects.

3.4.3.1. R&D activities

The main interest in this section is how various sources of knowledge contribute to innovation as well as how any hampering factors hinder innovation. It can be observed that IN_RD has positive and significant effects on any type of innovation and innovation success. By contrast, EX_RD's has no significant impacts on innovation and innovation success. Evidence that IN_RD is the only source of knowledge that positively and significantly affects all types of innovation and innovation success may suggest that IN_RD plays a more important role than the rest of the sources of knowledge. Therefore, based on this finding, Hypothesis 2a is supported.

3.4.3.2. Informal knowledge and formal cooperation

Turning to informal knowledge, different sources of informal knowledge used in the innovation transformation activity have different impacts on types of innovation and innovation success. Among market/commercials networks, knowledge transformed from *customers* positively and significantly affects product innovation, product innovation new to the firm, marketing innovation and innovation success. While knowledge transformed from *competitors* positively and significantly affects product innovation new to the market, process innovation and marketing innovation. Surprisingly, knowledge from science institutions only influences process innovation and this finding differs compared from most previous studies that show a positive influence of science institutions on radical innovation. Knowledge that is generated from association (industry association and entrepreneurs) is more likely to influence innovation and innovation success in significant and negative ways. Open sources (*events*) contribute positively to product innovation, product innovation that new to the market, product innovation that new to the firms and innovation success.

In relation to formal knowledge, cooperation with *suppliers* is the only factor that positively and significantly affects innovation, including product innovation, product innovation that new to the firms, marketing innovation and innovation success. Conversely, cooperation with consultants negatively and significantly impacts product and product innovation that new to the firms. The rest of the cooperation activities have no impact on innovation and innovation success. Based on these results, a pattern for how diverse sources of knowledge influence innovation and innovation success can be established. *First*, internal R&D is the most important source of knowledge that positively contributes to innovation and innovation success. *Second*, in the comparison between informal and formal knowledge, informal knowledge is more strongly associated with innovation and innovation success than formal knowledge.

Third, both informal knowledge and formal cooperation are more likely to influence technological innovation (product and process innovation) than non-technological innovation (organisational and marketing innovation). Therefore, Hypothesis 2b in this study is supported.

3.4.3.3. Innovation barriers and innovation

It can be observed that various constraints influence innovation adopted by firms differently. Individually, financial and knowledge constraints tend to influence innovation, while barriers related to the market and institutions tend to affect innovation less. PRODINOV is significantly and positively affected by constraints related to staff resistance towards change (INBAR_STAFF). Constrains related to employees (INBAR_STAFF and INBAR_MGR) have positive and significant impacts on new to the market innovation (PRODINOV_NEW2MARKET). In contrast, such innovation is negatively and significantly influenced by INBAR_EXFUND, INBAR_PERSON, INBAR_COOP and INBAR_INFRA affect PRODINOV_NEW2MARKET. Incremental innovation (PRODINOV_NEW2FIRM) is negatively impacted by barriers related to infrastructure (INBAR_INFRA). This pattern clearly differentiates constraints that effect radical and incremental innovations.

In the case of PROCINOV, two barriers related to INBAR_CUSTOM and INBAR_INFRA influence such innovation in different directions, negative and positive, respectively. ORGINOV is positively affected by INBAR_EXFUND and negatively affected by INBAR_COST. Four types of constraints affect MKTGINOV. Significant positive influences come from INBAR_EXFUND, INBAR_ORG and INBAR_COOP while INBAR_LABOUR negatively and significantly affects such innovation. Interestingly, innovation success (INN_SUCCESS) only correlates with knowledge that influences the success of innovation differently (see model 7 in Table 3.8). In addition, the direction of the relationship between barriers and INN_SUCCESS tends to be more negative. This indicates that after the firms performed innovation, barriers have more of a role to play in preventing them from becoming more innovative firms. Constraints related to INBAR_PERSON, INBAR_COOP and INNBAR_INFRA negatively and significantly affect innovation success, while INBAR_MGR has positive impact. Positive impacts of innovation barriers on innovation and innovation success indicate that they are revealing barriers, which means that when innovators face barriers in the innovation activities process, these barriers do not prevent them from performing the innovation activities, but that consciousness and knowledge is gained through the direct experiences in overcoming the barriers (D'Este et al., 2012). In contrast, negative directions may be evidence of deterring effects when there is a reverse causality between the innovation barriers' perception and innovation, resulting in innovation activity being significantly reduced by the existence of obstacles (e.g. Mohnen and Röller, 2005; Savignac, 2006; Tiwari et al., 2007). Therefore, based on this finding, Hypothesis 2c can be partially supported.

In relation to firm resources, most variables have weak and negative effects on diverse types of innovation and innovation success. Only firms age and multi-national ownership influence innovation in significant and negative directions. Firm age has a weak negative and significant association with MKTGINOV. The same direction was found for the influence of multi-national firm status on ORGINOV.

Table 3.8 Knowledge transformation activity

INDEPENDENT VARIABLES	Model 1 PRODINOV	Model 2 PRODINN_N2M[1]	Model 3 PRODINN_N2F[2]	Model 4 PROCINOV	Model 5 ORGINOV	Model 6 MKTGINOV	Model 7 INN_SUCCESS[3]
INTERNAL_RD	**.133***(.022)**	**.069***(.023)**	**.126***(.022)**	**.188***(.019)**	**.231***(.018)**	**.162***(.022)**	**8.342**(3.295)**
EXTERNAL_RD	.039(.065)	.077(.057)	.080(.067)	.093(.074)	.096(.074)	-.091(.069)	6.853(7.118)
Market & commercials							
SUPPLIERS	-.027(.027)	-.026(.027)	-.021(.027)	-.004(.027)	-.007(.026)	.017(.027)	-5.139(3.724)
CUSTOMERS	**.062**(.025)**	.039 (.025)	**.053**(.025)**	-.027(.025)	-.036(.025)	**.099***(.025)**	**6.122*(3.470)**
COMPETITORS	-.003(.025)	**.046*(.024)**	.004(.025)	**.042*(.024)**	.001(.025)	**.053**(.026)**	3.970(3.364)
CONSULTANTS	.001(.051)	-.012(.048)	.009(.052)	-.075(.049)	-.002(.052)	.003(.053)	-5.513(6.529)
COMMLAB	.043(.053)	.013(.049)	.067(.054)	.060(.050)	-.004(.049)	.022(.054)	3.486(6.499)
Science							
UNIVERSITIES	.030(.063)	.059(.058)	.061(.065)	**-.123**(.059)**	-.041(.061)	.036(.068)	6.438(7.874)
POLYTECHNIC	.053(.073)	.033(.068)	.001(.071)	**-.132*(.068)**	.055(.066)	-.006(.070)	6.574(8.503)
GOVERNMENT_RD	-.098(.060)	-.030(.059)	-.073(.061)	**.109*(.064)**	-.028(.060)	-.050(.064)	-1.260(7.652)
NON_PROFIT_RD	-.022(.022)	.026(.053)	-.032(.056)	**.149***(.057)**	-.045(.058)	.057(.061)	6.800(7.084)
Associations							
INVESTORS	.057(.057)	.036(.034)	**.068*(.036)**	**.058*(.035)**	.056(.035)	-.048(.036)	0.776(4.696)
IND_ASSOC.	-.056(.041)	**-.095**(.039)**	**-.087**(.041)**	-.036(.040)	.058(.043)	-.017(.044)	-8.185(5.473)
ENTREPRENEURS	**-.059***(.031)	-.043(.031)	-.051(.031)	-.017(.030)	.013(.031)	-.049(.032)	**-6.954*(4.188)**
Open resources							
EVENTS	**.189***(.038)	**.164***(.033)**	**.174***(.037)**	.028(.033)	.044(.035)	.026(.036)	**16.800***(4.387)**
SCIENCE_PUB.	-.033(.044)	-.047(.041)	-.010(.044)	-.022(.040)	-.040(.043)	-.012(.045)	-5.755(5.279)
INTERNET	-.039(.032)	-.029(.031)	-.040(.032)	-.024(.031)	.023(.032)	-.031(.034)	-2.148(4.210)
Formal cooperation							
COOP_GROUP	.040(.080)	.086(.070)	.008(.076)	.066(.083)	.009(.080)	-.067(.086)	.700(8.424)
COOP_SUPP	**.138**(.058)**	.085(.053)	**.117**(.057)**	.050(.056)	-.024(.061)	**.217***(.067)**	**14.215**(6.957)**
COOP_COMPET	-.078(.099)	-.104(.092)	.011(.102)	.147(.149)	-	**-.222*(.131)**	-13.178(12.979)
COOP_CONSUL	**-.238**(.094)	-.098(.089)	**-.242**(.097)**	.136(.109)	.154(.118)	.068(.116)	-12.253(11.271)
COOP_LAB	.081(.155)	-.071(.143)	.046(.156)	.177(.170)	.260(.175)	-.176(.172)	-.269(20.723)
COOP_UNIV	.063(.123)	-.026(.100)	.104(.130)	.094(.117)	.061(.130)	-.001(.137)	-9.742(12.586)
COOP_GOVRD	.060(.138)	.053(.118)	.001(.147)	-.044(.156)	-.257(.161)	-	14.251(15.708)

COOP_ASSOC	-.001(.117)	-.089(.107)	-.076(.115)	-.100(.117)	.102(.163)	.168(.185)	-7.773(15.215)
Financial constraints							
INBAR_INFUND	.022(.032)	.005(.032)	.034(.033)	.017(.031)	-.050(.031)	-.008(.033)	-2.102(4.356)
INBAR_EXFUND	-.026(.031)	**-.077**(.030)**	-.018(.031)	-.008(.029)	**.078***(.030)**	**.063**(.030)**	-4.611(4.098)
INBAR_COST	.003(.025)	.014(.025)	.000(.025)	.026(.024)	**-.071***(.025)**	.015(.025)	2.546(3.475)
INBAR_RISK	-	-	-	-	-	-	-
Knowledge constraints							
INBAR_STAFF	**.064**(.031)**	**.077**(.030)**	.043(.031)	-.029(.030)	.000(.030)	-.007(.031)	6.715(4.139)
INBAR_MGRINN	.060(.039)	**.120***(.038)**	.059(.039)	.051(.037)	.041(.039)	-.018(.040)	**13.696***(5.016)**
INBAR_ORGINN	-.040(.037)	-.033(.037)	-.030(.038)	.012(.037)	.008(.038)	**.075*(.041)**	-7.243(5.129)
INBAR_PERSON	-.001(.030)	**-.076**(.031)**	.008(.031)	-.002(.029)	-.011(.030)	.020(.031)	**-11.001***(4.234)**
INBAR_TECH-INFO	.014(.030)	.009(.031)	.023(.031)	-.003(.030)	-.025(.030)	-.037(.031)	-.802(4.211)
INBAR_MKT-INFO	-.002(.032)	-.001(.033)	.007(.032)	-.013(.031)	-.024(.032)	-.007(.033)	-.702(4.383)
INBAR_COOP	-.040(.027)	**-.051*(.027)**	-.023(.027)	-.005(.026)	.027(.027)	**.045*(.027)**	**-8.151**(3.696)**
INBAR_LABOUR	.012(.031)	-.013(.031)	.010(.031)	-.004(.030)	-.043(.031)	**-.064**(.031)**	3.06 (4.203)
Market constraints							
INBAR_MKTDOM	-.009(.026)	-.034(.026)	-.005(.027)	.015(.025)	.010(.027)	.019(.027)	-3.895(3.647)
INBAR_UNCERDEMAND	.019(.029)	.007(.029)	.010(.029)	.019(.028)	.014(.029)	.010(.030)	5.877(3.990)
INBAR_CUSTOM	-.008(.031)	-.005(.031)	.005(.031)	**-.051*(.030)**	.039(.031)	.012(.032)	-.987(4.316)
Institutions constraints							
INBAR_INFRA	-.041(.029)	**-.053*(.030)**	**-.055*(.029)**	**.066**(.029)**	-.002(.030)	-.027(.031)	**-7.931*(4.155)**
INBAR_INDUSTRY	.034(.046)	.058(.044)	.031(.046)	.017(.044)	.003(.044)	-.018(.047)	5.244(5.831)
INBAR_GOVREG	-.030(.044)	-.014(.044)	-.055(.045)	.019(.043)	-.009(.042)	.053(.046)	.29 (5.717)
Firm resources							
SIZE	-.00002(.000)	-.00003(.000)	-.00001(.000)	.00004(.000)	-.00002(.000)	-.00001(.000)	-.001(0.004)
AGE	.00 (.001)	.0001(.001)	.0002(.001)	-.001(.001)	.0003(.001)	**-.001*(.001)**	.009(0.114)
EXPORT	.0004(.000)	.001(.000)	.001(.000)	.00004(.000)	-.001(.000)	.00002(.000)	.056(0.054)
OWN_NATIONAL	.038(.062)	.001(.060)	.049(.062)	.037(.060)	-.064(.055)	.049(.059)	1.596(7.825)
OWN_MULTI	.006(.073)	-.049(.074)	.006(.073)	.007(.073)	**-.130*(.070)**	.011(.072)	-4.198(9.789)
OWN_JOIN	-	-	-	-	-	-	-
OPS_PLANT	.027(.039)	.010(.040)	.051(.040)	.004(.039)	-.014(.039)	.031(.039)	.601(5.286)

OPS_HEAD	-	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-	-
MED_LOW TECH	**.051(.029)***	.036(.030)	**.058(.029)****	-.009(.029)	.012(.030)	-.010(.029)	4.267(3.988)
MED_HIGH TECH	.036(.038)	**.063(.038)***	.041(.038)	.014(.038)	-.046(.037)	.049(.037)	5.827(5.206)
HIGH_TECH	.106(.110)	.171(.118)	.130(.108)	**-.175(.095)***	.039(.109)	.010(.122)	13.248(14.064)
EDU_UNDERHS	-.001(.001)	-.001(.001)	-.002(.001)	-.0001(.001)	-.0004(.001)	-.0002(.001)	-.235(.172)
EDU_HIGHSCHOOL	-.001(.001)	-.002(.001)	-.002(.001)	-.0003(.001)	-.0003(.001)	-.002(.001)	-.201(.182)
EDU_DIPLOMA	-.003(.003)	-.002(.002)	-.004(.002)	-.003(.002)	-.002(.003)	-.002(.003)	-.225(.330)
EDU_UNDERGRAD	-	-	-	-	-	-	-
RD_STAFF	-.001(.002)	.0003(.002)	-.002(.002)	-.001(.002)	-.001(.002)	.0001(.002)	.188(.226)
Number of obs	1179	1179	1179	1179	1165	1170	1179
LR chi2(57)	685.65	546.38	652.18	641.39	572.46	720.65	517.02
Prob > chi2	.000	.000	.000	.000	.000	.000	.000
Pseudo R2	.439	.3862	.4241	.4327	.401	.4519	.1192
Log likelihood	-438.107	-434.124	-442.875	-420.422	-427.534	-437.063	-1909.790
Mean VIF	3.50	3.50	3.50	3.50	3.50	3.50	3.50

*Note: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in model 1-6 are marginal effects generated from logit models*
[1]Product innovation new to the market; [2]Product innovations new to the firms; [3]Innovation success derived from Tobit regression

In line with Table 3.8, Table 3.9 also presents the second link in the IVC, knowledge transformation activity. In Table 3.9, the impact of external search breadth (BREADTH) and external breadth squared ($BREADTH^2$) are tested against innovation and innovation success. In addition, different groups of innovation barriers against innovation and innovation success are also tested. However, prior to that, factor analysis is performed to group 18 types of barriers (see Appendix 3.3 for factor analysis output).

The impact of internal R&D (IN_RD) on all types of innovation and innovation success is positive and significant. There is only a marginal significant impact of external R&D (EX_RD) on organisational innovation. Following Laursen and Salter (2006, p. 135), external search breadth is defined as 'the number of different search channels that a firm draws upon its innovative activities'. Therefore, in this study, BREADTH ranges from 0 to 15, being 0 when no external knowledge is used and 15 when all external knowledge is used. BREADTH has positive and significant impacts on all types of innovation and innovation success. This finding confirms that external search breadth is an important factor in explaining innovation and innovation success. BREADTH squared negatively and significantly affects innovation and innovation success, showing that when firms use too many external knowledge sources, there are diminishing returns. In the case of formal knowledge, cooperation activities with suppliers significantly and positively affect innovation (i.e. PRODINOV, product innovation new to the firms, and MKTGINOV) and innovation success. On the contrary, formal cooperation with consultants negatively and significantly impacts PRODINOV and product innovation new to the firms.

Based on the factor analysis, outputs can be grouped into four different innovation barriers, namely *market and institutions* (INBAR 1), *financial and risk* (INBAR 2), *employee and organisation* (INBAR 3), and *knowledge and cooperation* (INBAR 4). Factor 1 is labelled market and institution barriers and consists of six barriers, including MARKET_DOMINATION, UNCER_DEMAND, CUSTOMER_ACCEPT, INFRASTRUCTURE, STANDARD and GOVREG. This group of innovation barriers deals with the external environment of firms. Based on factor analysis, previous studies also classified constraints related external environment (e.g. Guijarro et al., 2009; Hadjimanolis, 1999).

Factor 2 is labelled financial and risk barriers and includes INFUND, EXFUND, RISK and COST. Obstacles related to financial resources is one of the most common barriers faced by firms that have been studied (e.g. Canepa and Stoneman, 2008; Efthyvoulou and Vahter, 2012; Ferrando and Ruggieri, 2015; Mohnen et al., 2008). Previous studies (e.g. Canepa and Stoneman, 2002; Mohnen et al., 2008) show that financial constraints have a significant and positive effect on three innovation activities, including prematurely stopping, seriously slowing down and not starting an innovation project. Policies that may be effective in overcoming financial constraints are tax subsidies and special financing schemes to support innovative firms (Mohnen et al., 2008).

Factor 3 is classified as employee and organisation barriers and includes three variables: STAFF_RESIST, MANAGER_RESIST and ORGRIGID. This type of barrier has also been discussed in

the previous studies (e.g. Guijarro et al., 2009; Hewitt-Dundas, 2006; Zwick, 2002). This group of barriers may be caused by a phenomenon called 'not invented here'. Employee resistance towards innovation is an important impediment that may be a source of irritation in industrial relations (Zwick, 2002). Therefore, it is crucial for firms to manage and handle such issues when they plan to innovate. Solutions to overcome this type of barrier were proposed by Zwick (2002) and include providing employment guarantees of bonus payments when the innovation is implemented successfully or a reduction in adoption costs of innovations.

Factor 4 is labelled knowledge and cooperation barriers and consists of PERSONNEL, TECH_INFO, MARKET_INFO and COOPERATION. Innovation barriers related to knowledge can be linked to the availability of required resources to acquire and process information used for innovation activities. Therefore it is often associated with absorptive capacity (Hölzl and Janger, 2014). To overcome this barrier, firms may perform regular activities such as training and workshops in order to improve or to upgrade employees' skills and knowledge.

INBAR 1 negatively and significantly affects ORGINOV but has no significant impact on innovation success. The same pattern can also be found in the influence of INBAR 2 on PRODINOV_NEW2MARKET and ORGINOV. This barrier has negative direction but insignificant impact on innovation success. Therefore, the first two groups of innovation barriers may be treated as deterring barriers. INBAR 3 influences PRODINOV_NEW2MARKET and innovation success in positive and significant directions. Lastly, INBAR 4 significantly affects both PRODINOV_NEW2FIRM and innovation success in different directions, positively and negatively, respectively. This may indicate that the last two innovation barrier groups can be classified as revealing barriers.

3.4.4. Knowledge exploitation activity

Table 3.10 displays the statistical output of OLS regression for knowledge exploitation activity. Because data on sales and employee growth are not available in the IIS 2011, this study uses productivity as the only indicator of firm performance, as presented in Table 3.10. In the first model PRODINOV is excluded. Strikingly, PRODINOV_NEW2MARKET and PRODINOV_NEW2FIRM innovations as well as INNOVSUCCESS have no significant effect on firms' performance that is proxied by productivity. When both PRODINOV and INNOVSUCCESS are excluded (model 2), there is no significant influence of either PRODINOV_NEW2MARKET or PRODINOV_NEW2FIRMS on productivity. In the third model, in which PRODINOV_NEW2MARKET and PRODINOV_NEW2FIRMS are excluded, there is no significant effect of PRODINOV and INNOVSUCCESS on productivity. Another surprising finding is that, in contrast, non-product innovations including PROCINOV, ORGINOV and MKTGINOV, significantly affect productivity in all models. Positive associations were found between both PROCINOV and ORGINOV and productivity; while a negative association was found between MKTGINOV and productivity. The evidence that INNOVSUCCESS has negative and insignificant impact on productivity is

in line with previous studies (Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). Based on these findings, Hypothesis 3 partially is supported.

Firm resources negatively and significantly affect productivity, but only in low-technology firms. Variables such as size, age, export and the lowest level of education have negative associations with productivity. In contrast, in high-tech firms, having employees with high school and under graduate degrees is positively associated with productivity.

Table 3.9 Knowledge transformation activity *(continued)*

INDEPENDENT VARIABLES	Model 1 PRODINOV	Model 2 PRODINN_N2M[1]	Model 3 PRODINN_N2F[2]	Model 4 PROCINOV	Model 5 ORGINOV	Model 6 MKTGINOV	Model 7 INN_SUCCESS[3]
INTERNAL_RD	**.132***(.022)**	**.071***(.023)**	**.125***(.022)**	**.181***(.018)**	**.227***(.017)**	**.148***(.023)**	**7.980**(3.215)**
EXTERNAL_RD	.040(.067)	.092(.060)	.084(.069)	.106(.075)	**.121*(.071)**	-.078(.070)	7.830(7.259)
Ext. search breadth							
BREADTH	**.113***(.009)**	**.095***(.011)**	**.110***(.010)**	**.109***(.010)**	**.096***(.009)**	**.116***(.008)**	**14.143***(1.604)**
BREADTH2	**-.005***(.001)**	**-.004***(.001)**	**-.005***(.001)**	**-.005***(.001)**	**-.005***(.001)**	**-.006***(.001)**	**-.592***(.089)**
Formal cooperation							
COOP_GROUP	.053(.081)	.108(.074)	.016(.075)	.049(.083)	-.008(.076)	-.047(.085)	3.815(8.508)
COOP_SUPPLIERS	**.125**(.061)**	.076(.056)	**.110*(.060)**	.047(.058)	-.012 (.060)	**.182***(.069)**	**13.416*(7.132)**
COOP_COMPETITORS	-.073(.103)	-.116(.097)	-.008(.106)	.146(.151)	-	-.148(.132)	-14.472(13.277)
COOP_CONSULTANT	**-.239**(.094)**	-.089(.094)	**-.245**(.095)**	.102(.115)	.177(.125)	.017(.114)	-15.660(11.510)
COOP_COMMLAB	.140(.168)	-.084(.155)	.140(.172)	.156(.182)	.179(.160)	-.188(.201)	-9.356(21.701)
COOP_UNIVERSITIES	.073(.115)	.021(.099)	.121(.121)	.075(.123)	.041(.122)	-.046(.127)	.721(12.700)
COOP_GOV-RD	-.020(.135)	-.022(.121)	-.049(.142)	-.056(.163)	-.245(.160)	-	2.631(16.030)
COOP_ASSOCIATION	-.025(.116)	-.147(.113)	-.094(.114)	-.075(.120)	.102(.149)	.163(.174)	-13.369(15.448)
Innovation barriers							
INBAR 1	-.0003(.009)	.006(.009)	-.004(.009)	.011(.009)	**-.018**(.008)**	-.011(.009)	1.045(1.261)
INBAR 2	-.002(.008)	**-.018**(.009)**	-.001(.009)	-.001(.008)	**-.014*(.008)**	.012(.008)	-1.360(1.172)
INBAR 3	.013(.009)	**.022**(.009)**	.009(.009)	-.001(.009)	-.011(.009)	.001(.009)	**2.264*(1.280)**
INBAR 4	.004(.010)	-.013(.010)	**.016*(.010)**	-.0001(.010)	.012(.009)	.014(.010)	**-2.273*(1.349)**
Firm resources							
SIZE	-.00001(.0003)	-.0000 (.0003)	-.00001(.000)	.00003(.000)	-.00002(.00003)	-.00002(.000003)	.00008(.002)
AGE	.0005(.001)	-.0002(.001)	.0002(.001)	-.001(.001)	.0003(.001)	-.001(.001)	-.019(.116)
EXPORT	.0003(.0004)	.0004(.0004)	.0005(.0004)	-.00004(.000	-.00004(.0004)	.00005(.0004)	.026(.055)
OWN_NATIONAL	-.020(.060)	-.061(.060)	-.008(.060)	.020(.060)	-.065(.054)	.019(.059)	-5.989(7.729)
OWN_MULTI	-.053(.073)	**-.130*(.074)**	-.057(.073)	.001(.072)	**-.119*(.069)**	-.009(.072)	-14.301(9.808)
OWN_JOIN	-	-	-	-	-	-	-
OPS_PLANT	.018(.040)	.013(.041)	.041(.041)	-.008(.040)	-.001(.039)	.036(.040)	.961(5.439)
OPS_HEAD	-	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-	-

MEDLOW_TECH	.038(.029)	.008(.030)	.046(.029)	-.033(.029)	.020(.029)	-.008(.029)	.030(4.043)
MEDHIGH_TECH	.029(.040)	.035(.040)	.036(.039)	-.005(.038)	-.055(.036)	.040(.039)	1.826(5.279)
HIGH_TECH	.090(.110)	.173(.117)	.115(.109)	-.142(.094)	.066(.108)	.019(.116)	13.931(14.095)
EDU_UNDERHS	-.001(.001)	-.001(.001)	-.002(.001)	-.001(.001)	-.0004(.001)	-.002(.001)	-.248(.175)
EDU_HS	-.002(.001)	-.002(.001)	-.002(.001)	-.001(.001)	-.0002(.001)	-.002(.001)	-.219(.184)
EDU_DIPLOMA	-.003(.003)	-.002(.003)	-.004(.003)	**-.004*(.002)**	-.002(.003)	-.003(.003)	-.289(.334)
EDU_UNDERGRAD	-	-	-	-	-	-	-
RD_STAFF	-.0003(.002)	.001(.002)	-.001(.002)	-.001(.002)	-.001(.002)	.001(.002)	.186(.227)
Number of obs	1179	1179	1179	1179	1165	1170	1179
LR chi2(57)	629.62	468.18	600.54	587.78	559.42	650.28	456.01
Prob > chi2	.000	.000	.000	.000	.0000	.000	.000
Pseudo R2	.403	.331	.391	.397	.392	.408	.105
Log likelihood	-466.126	-473.226	-468.696	-447.225	-434.054	-472.247	-1940.297
Mean VIF	4.57	4.57	4.57	4.57	4.57	4.57	4.57

Note: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in model 1-6 are marginal effects generated from logit models; [1]Product innovation new to the market; [2]Product innovations new to the firms; [3]Innovation success derived from Tobit regression; INNBAR 1 = barriers related to market and institutions; INNBAR 2 = barriers related to financial and risk; INNBAR 3 = barriers related to employee and organisation; INNBAR 4 = barriers related to knowledge and cooperation

Table 3.10 Knowledge exploitation activity

INDEPENDENT VARIABLES	Model 1 PRODUCTIVITY	Model 2 PRODUCTIVITY	Model 3 PRODUCTIVITY
PRODINOV	-	-	268.160(716.413)
PRODINOV_NEW2MARKET	668.224(1122.881)	-289.371(832.420)	-
PRODINOV_NWE2FIRM	-45.167(820.431)	48.857(817.301)	-
PROCINOV	**1964.657***(631.219)**	**1985.895***(631.165)**	**1985.412***(629.213)**
ORGINOV	**2511.089***(631.492)**	**2578.718***(629.410)**	**2518.678***(632.025)**
MKTGINOV	**-1756.931***(604.736)**	**-1767.292***(604.841)**	**-1746.373***(603.329)**
INNOVSUCCESS	-29.379(23.128)	-	-21.282(18.660)
Firm resources			
Size	-.074(.184)	-.077(.184)	-.075(.184)
Age	-22.201(19.116)	-22.262(19.121)	-22.451(19.115)
Export	-7.785 9.670)	-7.583(9.672)	-7.678(9.661)
OWN_NATIONAL	362.853(1241.632)	371.125(1241.944)	351.187(1241.068)
OWN_MULTI	1109.779(1566.056)	1101.907(1566.458)	1076.938(1565.01)
OWN_JOIN	-	-	-
OPERATION_PLANT	-1003.043(879.703)	-986.841(879.843)	-997.590(879.377)
OPERATION _HEAD	-	-	-
LOW_TECH	-	-	-
MEDLOW_TECH	580.331(649.173)	580.257(649.345)	577.387(648.739)
MEDHIGH_TECH	**2005**(912.806)**	**2044.913**(912.506)**	**2025.741**(911.861)**
HIGH_TECH	2421.285(2542.052)	2457.057(2542.568)	2477.757(2539.589)
EDU_UNDERHS	-48.366(31.223)	-47.312(31.220)	-48.391(31.215)
EDU_HIGHSCHOOL	-43.934(33.014)	-43.345(33.020)	-44.058(33.000)
EDU_DIPLOMA	-44.996(58.843)	-44.698(58.858)	-45.006(58.821)
EDU_UNDERGRAD	-	-	-
RD_STAFF	11.331(37.141)	10.115(37.138)	11.454(37.121)
Obs.	1179	1179	1179
F ( )	2.92	3.00	3.07

Prob > F	.000	.000	.000
R^2	.046	.044	.046
Adj. R^2	.030	.030	.031
Root MSE	8272.30	8274.50	8270.00

*Notes: Significant levels *p≤10, **p≤05, ***p≤001. The results are based on OLS regressions.*

3.5. Discussion and Conclusions

This study investigates and models the IVC that encompasses knowledge sourcing, transformation and exploitation activities of Indonesia manufacturing firms using data from the IIS 2011. The literature on the IVC framework has been widely used to analyse inter-relationships among firm interaction, innovation, business growth and productivity in developed countries, however, based on the reviewed literature there is no empirical evidence on the IVC in the context of Indonesia. Therefore, this study sheds light on the nature of interrelationships within each stage and between linkages of the IVC performed by Indonesian firms.

Key findings of this study are as follows. First, in the first link of the IVC, this study finds the existence of strong synergistic relationships between internal R&D and external sources of knowledge as well as among external sources of knowledge. This may indicate a similar pattern of knowledge sourcing activity to that in developed countries, namely the implementation of "open innovation strategy" that up to this time has not been explored. The role of external networks tends to be less important when the firms already source knowledge for innovation from external R&D activities. External actors from market/commercial groups (i.e. customers and competitors) have important roles as knowledge providers if the firm also generates knowledge from internal R&D. In contrast, the firms' interactions with scientific institutions tend to be of lesser importance. The firms that source knowledge from market/commercials network interact less with scientific institutions, but they do interact with their own networks, associations and open sources. A synergistic relationship can also be found among science institutions. In relation to formal cooperation, firms tend to restrict cooperation with firms within the same group and with suppliers when they perform internal or external R&D activities.

Second, in the second link of the IVC, internal R&D plays important roles and has strong positive impacts on all types of innovation and innovation success. External knowledge that shows similar patterns in shaping innovations mainly comes from informal knowledge from customers and competitors and from formal cooperation with suppliers. Knowledge generated from scientific institutions makes no significant contribution to innovation and innovation success. Positive impacts on process innovation come only from government and non-profit R&D, while university and polytechnic sources contribute negatively to process innovation. This contradicts previous studies stating that novel and highly advanced innovation requires greater levels of R&D, patents or knowledge from science institutions such as universities and research centres (Amara and Landry, 2005; Todtling et al., 2009).

External breadth of knowledge is also tested and the results show that the greater the number of external knowledge sources used, the better are innovation and innovation success. However, evidence shows that using too many sources of external knowledge results in diminishing returns, as demonstrated by the negative impact of external breadth squared on innovation and innovation success.

In terms of innovation barriers, individual constraints affect innovation and innovation success differently. Factors hampering innovation are mainly financial and knowledge factors. Of adopted innovations, product innovations that are new to the market are affected by a greater number of barriers than other types of innovation. Constraints related to external sources of funding, personnel, cooperation and infrastructure negatively and significantly affect product innovations that are new to the market, while hampering factors associated with staff and manager resistance towards change affect innovation positively and significantly. These two situations may hinder firms in producing more novel innovation.

Organisational innovation is affected positively by lack of external funding and negatively by high cost of innovation. Knowledge related barriers such as organisational rigidity, lack of cooperation and labour allocation are the main barriers to marketing innovation. Knowledge-based innovation barriers as a group significantly affect innovation success. Therefore, it may be concluded that different innovation barriers influence innovation in different ways and this confirms the results of a study conducted by Guijarro et al. (2009). Factor analysis output identified four groups of innovation barriers, namely "market and institution", "financial and risk", "employee and organisation" and "knowledge and cooperation" related barriers. The first and the second groups of barriers tend to influence innovation in negative directions and this may indicate the existence of deterring barriers. In contrast, the third and fourth groups of barriers positively affect innovation, identifying them as revealing barriers.

Third, the final link of the IVC relates to the impact of innovation on productivity provides surprising results. In general, product innovations new to the market and new to the firm as well as innovation success have no significant impact on productivity. The fact that innovation success is negatively associated with productivity may prompt questions related to the quality of innovative products that may be not able to disrupt the market and this may severely impact the firms' sales and further impact productivity.

The finding that neither product innovations new to the market and new to the firm nor innovation success lead to productivity, perhaps due to the firms' efforts to detect and overcome any weak links in the IVC to boost productivity. First, sourcing activity that relies on synergy between internal R&D and external networks, mainly from market/commercials, automatically influences the minimum usage of other sources of knowledge such as scientific institutions that may provide additional added value for firms. In this sense, a diverse open innovation strategy may need to be implemented with the hope that the use of more diverse and better-quality sources of knowledge able to overcome the weak links in knowledge sourcing activities. Second, the low quality of firms' human resources may contribute to the success of knowledge sourcing, transformation and exploitation as indicated by no positive contributions to the three links of IVC. Third, diverse of innovation barriers that hamper Indonesian manufacturing firms may affect the success of the IVC activities. Lastly, environments external to the firms, or a weak conditional framework for innovation in Indonesia, may contribute indirectly to the success of the IVC activities.

Findings from this study are expected to enrich literature of innovation studies in the context of developing countries in several ways. First, the fact that non-technological innovation (i.e. marketing innovation) is the highest proportion of innovation produced by Indonesian manufacturing firms support and confirm previous studies that reveal most firms in in developing countries: tend to focus on market rather than technological innovation (Wamae, 2009), beyond traditional focus on R&D (Srholec, 2008), and attempt to reach the technological frontier instead of achieving inventions that are new to the market (Hou and Mohnen, 2013). Second, the highest proportion of knowledge sourced by Indonesian manufacturing firms mainly from informal source of knowledge e.g. customers and competitors. This also confirms previous innovation studies in Indonesia that reveal innovation in Indonesian manufacturing sectors generally as the results of learning through "informal experiences" not through "formal scientific activity or R&D" (Aminullah, 2012; Aminullah et al., 2014).

3.5.1. Innovation policy implication

Based on the findings from the first and second links of the IVC, relevant innovation policies may be proposed. The fact that Indonesia faces problems related to scientific institutions such as "low public and private investment in R&D", "a low-ranking higher education and training system" and "a small number of researchers and scientists for a country of its size" (OECD, 2013, p. 175), may present a problem for synergistic relationships between scientific institutions and other external agents. Further impact is clearly seen in the second link of the IVC in which the knowledge used from scientific institutions, both informally and formally, negatively impacts innovations. Therefore, government policy, for instance, promoting a triple helix strategy that involves university-industry-government interaction and partnership, may help address these challenges to improve knowledge transfer by integrating the three types of institutions. As argued by Tambunan (2005), triple helix implementation in Indonesia has been relatively slow. The Indonesian government initiated the development of incubators and science parks in 1990 with UNDP's support, but the development of these incubators has been very slow (Simamora, 2009). In 2015, under the new government, the Research and Technology and Higher Education Ministry launched a new plan to build 100 techno parks to boost the national economy through the development and application of science and technology (Jakarta Post, 2015). Public scientific institutions such as techno parks may be used by Indonesian firms to generate knowledge from R&D activities when they lack sufficient internal funds.

Evidence showing that financial constraints hinder innovation can be used as the trigger to promote R&D policies for private sector R&D funding and R&D tax credits. From the firms' perspective, internal constraints such as resistance from staff and managers, lack of qualified personnel and lack of cooperation with external agents also need to be addressed. Furthermore, labour quality as indicated by low education levels does not support positive contributions for any of the three IVC links. In this sense, regular programs such as training, workshops and advanced education to enhance employees' knowledge and skills are very

important. Important issues such as a syndrome called ‘not invented here’ and ‘open innovation’ also need to be emphasised as the two approaches may play important roles in the success of knowledge sourcing and transformation activities.

3.5.2. Limitation of the study

Finally, limitations of this study need to be acknowledged. First, issues related to firms’ sectors has not been discussed in this study and as a result, sectors’ effects on the three links of IVC cannot be detected. The variation among firm sectors is only derived from the classification of technology intensity. Second, this study uses IIS 2011 data that is restricted to manufacturing firms. The comparison of the IVC activities between manufacturing and service firms may provide fruitful insight into innovation policies for Indonesia. Therefore, these issues should be studied in the future research. Third, this study is a cross-sectional in nature i.e. the study only portrays IVC based on IIS 2011 data, as a result dynamic of Indonesian manufacturing firms’ IVC is missing. Hence, future studies may address this limitation by conducting a longitudinal study.

CHAPTER 4 – PAPER 3

SOURCING, TRANSFORMING AND EXPLOITING KNOWLEDGE FOR INNOVATION: A COMPARISON BETWEEN INDONESIA AND UK MANUFACTURING FIRMS

4.1. Introduction

Innovation is considered to be an engine of productivity growth in both developing and developed economies. However, successful innovation in each kind of country is different as firms face and experience different barriers that hinder innovation activities (see Chapter 2)[3]. Firms in emerging economies tend to experience substantial institutional, resource and capability barriers that affect successful innovation (Fu et al., 2015). Furthermore, innovation performance that is shaped by innovation system between developing and developed economies are different. Based on this situation, this study aims to compare innovation value chain (IVC) that consists of three main activities such as knowledge sourcing, transformation and exploitation between manufacturing firms in developing and developed economies using Indonesia and the UK as examples.

Existing comparative studies between Indonesia and other countries tend to focus on firms' technological capabilities and their growth and development. For example, studies have examined determinants of technological capability, including internal factors, external factors and technology transfer modes between Indian and Indonesian manufacturing firms (Madanmohan et al., 2004); a comparison of technological development and growth between Indonesia and Thailand (Frankema and Lindblad, 2005); a comparison of development strategies in Indonesia and China (Hofman et al., 2007); technological capability differences between Indonesian and Malaysian automotive firms (Rasiah, 2009); and new product development process differences between Indonesian and Taiwanese manufacturing firms (Jeng Wang et al., 2012). However, there is no existing IVC study that compares Indonesia with UK firms. This study fills this gap by comparing the IVCs of Indonesian and UK manufacturing firms. The research question that is addressed is: *"To what extent are knowledge sourcing, transformation and exploitation performed differently by Indonesian and UK manufacturing firms?"*

In the case of Indonesia, existing studies on knowledge sourcing and use activities tend to focus on case studies in specific industries, such as collaboration and innovation adoption in small-scale roof tile clusters (e.g. Sandee and Rietveld, 2001); innovation and information flow in small-scale cottage industries in a rural areas (e.g. Kristiansen, 2002); sources of knowledge in small furniture industries (e.g. Van Geenhuizen and Indarti, 2005); social networking and innovation of SMEs in handicraft industries (e.g. Brata, 2011); innovation and cooperation activities of SMEs in food processing industry clusters (e.g. Najib

[3] Chapter 2 of this thesis entitled "Knowledge sourcing strategies and innovation barriers across manufacturing firm in high- and middle-income countries."

and Kiminami, 2011); and knowledge sourcing activities of Indonesian automotive industries (e.g. Aminullah and Adnan, 2012). Apart from these studies, a recent study on the IVC based on data derived from the Indonesia Innovation Survey (the IIS) 2011 that may be comparable to the IVC studies in developed countries was conducted (see Chapter 3)[4]. That study sheds light on how Indonesian manufacturing firms source, transform and exploit knowledge. Meanwhile, several IVC studies on Ireland and the UK have been conducted (Battisti and Stoneman, 2013; Doran and O'Leary, 2011; Ganotakis and Love, 2012; Roper et al., 2008). Therefore, these studies can be used as the cornerstone for comparing the IVC activities between Indonesian and UK firms.

This study is worth conducting for the following reasons. *First,* despite that comparative studies of the IVC is not new to the literature, it is important to understand the IVC comparison between developing and developed economies, and such a study does not currently exist. This study will provide analysis on the micro-level of the differences in IVCs between developing and developed countries, and will include determining which specific knowledge is sourced by the firms, the impact of the sourced knowledge on innovation and the impact of innovation on the firm performance. *Second,* this study investigates broader sources of knowledge that are classified into R&D activities, informal knowledge and formal cooperation. Furthermore, the impacts of knowledge transformation on both technological and non-technological or wider innovation and then the effects of exploitation of both types of innovation on the firm performance are tested. While previous comparative IVC studies tend to focus on internal R&D (e.g. Janz et al., 2007); internal R&D and market agents (e.g. Griffith et al., 2006); or internal R&D, public R&D and market agents (e.g. Roper and Arvanitis, 2012) as the sources of knowledge, these studies only measure impact of knowledge on technological innovation. Implementing technological innovation, that normally consist of product and process innovation, in isolation has been criticised for several reasons. *First,* performing innovation in firms is not only about developing and implementing of new technology but also about organising and implementing business routines, management, marketing and organisational competencies (e.g. Baranano, 2003; Boer and During, 2001; Mothe and Thi, 2010). *Second,* innovation management literature suggests that integration of products, processes and organisational innovation is important to successfully transferring new ideas and new business opportunities to the market (e.g. Cozzarin and Percival, 2006). *Third,* a combination technological and non-technological innovation has a positive impact on firms' sales (e.g. Schmidt and Rammer, 2007).

Based on empirical evidence from previous Indonesian and UK IVC studies, it is anticipated that the interesting parts of this study that will distinguish it from previous IVC studies lie in the usage of R&D and non-R&D (informal knowledge and formal cooperation) as the inputs to innovation, the involvement of wider innovation and the existence of different innovation barriers faced by Indonesian and UK firms.

[4] Chapter 3 of this thesis entitled "How knowledge is sourced, transformed and exploited in the innovation value chain: Firm-level analysis from Indonesian manufacturing firms"

Evidence shows that manufacturing firms in middle-income countries make more use of external knowledge than the firms in high-income countries (see Chapter 2). In the same vein, the proportion of Indonesian manufacturing firms that source from informal knowledge such as customers is greater than those sourcing from internal R&D (see Chapter 3). Irish and UK IVC studies show that firms sourcing knowledge from internal R&D are more prevalent than firms sourcing external knowledge (Doran and O'Leary, 2011; Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). Furthermore, manufacturing firms in middle-income countries, including Indonesia, face more innovation barriers than their counterparts in high-income countries (see Chapter 2). According to the Indonesian IVC studies, both technological and non-technological innovation are found to positively and significantly affect the firm performance that is proxied by productivity (see Chapter 3), while non-technological innovation involvement could not be found in the studies of Ireland and the UK (e.g. Doran and O'Leary, 2011; Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). This may lead to different causal links from knowledge sourcing through innovation to productivity between Indonesia and UK firms.

The following sections of this study are organised as follows. Section 4.2 discusses innovation system comparison between Indonesia and countries in Southeast Asia region and between the UK and EU countries members. Subsequently, the section also presents the conceptual foundation and hypotheses related to the three IVC links and their comparison between Indonesia and UK. Section 4.3 explains the data sources and methods used in this study. Section 4.3 describes the data, variables and methods for testing the proposed hypotheses. Section 4.4 reports the results and details to what extent the proposed hypotheses have been confirmed. The final section, Section 4.5, contains the discussion and conclusions.

4.2. Conceptual foundation and hypotheses development

4.2.1. Innovation system comparison

In this section, comparison of innovation system between Indonesia and countries in Southeast Asia region is discussed. In this case, measuring innovation performance and linkages is challenging for non-OECD countries where data is relatively scarce and where traditional indicators, such as R&D expenditures are perhaps less relevant. Similar comparison between the UK and European Union (EU) member countries is also presented. These comparisons may provide a coherent view and insights on linkages among actors and snapshots of science, technological and innovation performance between developing and developed economies in different regions.

In terms of income level, the lower-middle income categories dominate Southeast Asian economies. Two countries (i.e. Singapore and Brunei Darussalam) are classified the high-income, two higher-middle-income countries (i.e. Malaysia and Thailand), and the rest of economies, including Indonesia, are in the lower-middle-income group. Indonesia has many similarities with a majority of ASEAN member countries. However, there is great diversity across the region between a high-income country like Singapore and

middle-income countries that have entered a process of catching up much more recently. The first generation of Asian Tigers (i.e. Chinese Taipei, Hong Kong, Korea and Singapore) used catching up strategy began with industrialisation and the development of their manufacturing base. Unlike the four pioneering Tigers, the second-generation Southeast Asian Tigers (i.e. Indonesia, Malaysia and Thailand) were heavily resource-based with little prior industrialisation (OECD, 2013).

Many ASEAN countries rely on traditional sources of economic growth (i.e. labour and physical capital), in order to support the long-term growth and to compete with the other rapidly advancing countries in Asia (e.g. China and India), the economic growth has to be driven by innovation e.g. performing own R&D. However, only a few ASEAN countries have achieved considerable level of innovation capabilities, while most of them have not (OECD, 2013). In terms of Indonesia, most Indonesian firms do not invest in R&D, they tend to rely on technologies developed elsewhere (Thee, 2005). Indonesia relies on a large extent on exports of natural resources and good trade links with leading global economies. Gammeltoft and Aminullah (2006) recommend three important issues to improve Indonesia innovation system that should be dealt with: (1) knowledge-based industrial transformation; (2) balanced technology absorption from R&D and learning; and (3) shifting the policy orientation from economic to techno-economic development.

Compared to most ASEAN countries, the majority of EU members have higher income levels and most of them are classified as high-income economies, including the UK. In terms of EU national innovation systems performance, the recent 2017 European Innovation Scoreboard (EIS) report, the UK along with Denmark, Finland, Germany, the Netherlands, and Sweden are grouped as innovation leaders (Euro Commission, 2017). The UK performance increased recently, starting in 2012 and accelerating in 2016. In the UK, innovation is a key driver of labour productivity growth and between 2000 and 2008, innovation contributed 63% of all labour productivity growth (BIS, 2011).

Public R&D (GERD) invested by ASEAN countries broadly aligns with their income levels (OECD, 2013). For example, Singapore's expenditure level more than 2%, however, most ASEAN countries (including Indonesia) spend between 0.05-0.2%. R&D activities are dominated by business sector in Singapore, Malaysia and the Philippines, the public sector is the dominant performer of R&D in other ASEAN countries. Although R&D is performed in business sector, it tends to be done largely in multi-national firms, even in a country like Singapore. Indonesia's investment in GERD has always been very small and it has never exceeded 0.2% and most of it has occurred in the public sector (Hill and Tandon, 2010). Of five ASEAN countries (i.e. Indonesia, Malaysia, Thailand, Vietnam, and the Philippines), only Indonesia had no experience in increasing scientific knowledge acquirement through R&D and since 2000 it constantly deteriorated and has occupied the bottom position (Aminullah, 2007). As the investment in GERD is relatively low and dominated by public funding with little contribution from private sectors, as a consequence, there is limited ability to mobilise the resources required for innovation (Baark, 2016). According to Aminullah (2012), the constantly low investment in national R&D due to the following three

reasons: (1) private R&D investment is very low; (2) large proportion of industries is dominated by low and medium technology industries that do not require R&D, and (3) government attention to support the development of STI is constantly declining.

In the case of UK, the country's total investment in R&D has been relatively static and remains lower than many of the world's other major economic powers, at around 1.8 % of GDP since the early 1990s and was around £ 27bn in 2011. The levels of investment have remained stable for a number of years throughout the economic crisis (BIS, 2014). While, other EU countries, such as France, Germany and Finland, invested on GERD more than 2% in 2011. GERD was the highest in South Korea and China exceeded the UK for the first time in 2011 (BIS, 2014).

In terms of R&D's performers, among ASEAN countries, Malaysia's business sector accounts for the largest share of GERD, with around 71% of total R&D in 2008, followed by Singapore (62%) and the Philippines (57%). By contrast, government contributes to the largest share of GERD, significantly more than the business sector in Indonesia, Brunei, Vietnam, and Lao PDR. Indonesian government institutes perform 81% of GERD (OECD, 2013). Unlike many OECD countries that business sector is the dominant of R&D funding, government funding of R&D is the most common funding source in Brunei, Indonesia and Vietnam. According to Gammeltoft and Aminullah (2006), there are two main problems related to public R&D activities in Indonesia: (i) lack of funding leading to difficulties in hiring qualified researchers; and (ii) lack of ties with the private sector, hence R&D programs are not responsive to the demands of industries.

In contrast, the business sector contributes significantly to R&D in the UK, accounting for around two-thirds of total GERD, but expenditure is concentrated in a small number of industries. In 2010, around 61% of all R&D in the UK was performed by businesses, while the rest of R&D performers were higher education (27%), government (9%), and the remainder was non-profit organisations (BIS, 2012). Businesses sectors are also the largest performers of R&D in other OECD countries such as Canada, Italy, France, Germany, Finland, and Japan.

The number of R&D personnel is an important indicator of a nation's scientific and technological capabilities and it includes all persons directly in R&D activities such as researchers, technicians, and support staff. Of ASEAN countries, the largest number of R&D personnel are in Indonesia, Thailand and Singapore (OECD, 2013). Although, Indonesia employs the largest number of R&D personnel in the region, the country only produced less than 5% of the region's scientific publications over 2000-2010 and only have few number of Patent Cooperation Treaty (PCT) applications. By contrast, Singapore dominates article output in the region, with around 200,000 articles during 2000-2010 that represent 44% of the regional total (OECD, 2013).

In 2009, the UK has the highest cumulative proportion of science and engineering doctoral graduates per 100,000 population among EU countries with a similar proportion of science doctoral to Germany and

France and second highest proportion of engineering students behind Finland (BIS, 2012). However, the number of researchers in the UK remained steady around 250,000 between 2007 and 2011 (BIS, 2014). In terms of scientific outputs, UK research has very high quality, examples of evidence: (1) the UK remains strong with 11.6% of the world's citations, behind just the USA and China; and (2) the UK accounts for 10.9% of all academic research cited by patents globally and this indicates a significant amount of commercially valuable research which has impact in both national and abroad levels.

In terms of science and technology performance, patent applications can be used as another way to measure R&D output. However, it is important to note that not all inventions are patented. Among ASEAN countries, Singapore leads in the number of Patent Cooperation Treaty (PCT) applications, then followed by Malaysia and Thailand. In contrast, Indonesia is behind the top innovating countries e.g. Korea, as well as its more immediate neighbour Malaysia, in terms of patents granted (Hill and Tandon, 2010). Referring to US Patent and Trademark Office (USPTO) data, the number of patents from Indonesia in the 1990s was relatively comparable with some ASEAN countries such as Malaysia, Thailand, and the Philippines. However, since the year 2000, the Indonesian position has fallen behind Malaysia and Thailand (Aminullah, 2007).

In the UK, data from the World Intellectual Property Organisation (WIPO) between 2000 and 2010, showing a longer-term decline in the UK patent publications across all fields (chemistry, electrical engineering, mechanical engineering, instruments, and other fields) since 2008, the year of the financial crisis (BIS, 2012).

ASEAN countries have variabilities not only in the GDP they generate but also in terms of business landscape. Agricultural sector contributes to a sizeable proportion of GDP in several less develop countries, while services is the most dominant sector in countries such as Singapore, Philippines and Malaysia. In addition, many countries in Southeast Asia regions are dominated by low and medium technology (LMT) industries that perform less formal R&D and normally it links to modification and incremental change.

In terms of linkages and knowledge flows, firms and industries are part of larger inter-linked systems involving market and non-market knowledge. In the case of UK, overall, a majority of innovative enterprises report formal cooperation arrangements and the national level of cooperation is the most common form to generate knowledge use for innovation input (BIS, 2011). By contrast, in Indonesia, knowledge use for innovation, especially in manufacturing sectors, is generated from learning through informal experiences and not through formal scientific activity or R&D intensity (Aminullah, 2012, 2014). Modes of learning can be: (1) *learning by doing* through working in the production floor; (2) *learning by using* through the use of machinery equipment and production systems; (3) *learning by interacting* through interaction with users, suppliers, parent companies in the design and modification of product and production process; and (4) *learning by modelling* through the successful of past experiences as a role model for the future (Aminullah, 2012, 2014).

Based on the aforementioned innovation system comparison, it can be concluded that the UK has better innovation system performance than Indonesia. In the UK, R&D may be a useful proxy for innovation, while in Indonesia the key process is technological capability development, learning through informal experiences. Hence, a priori these contrasts related to the IVC is stronger linkages between knowledge sourcing, transformation, and exploitation in the UK.

4.2.2. Innovation value chain

The IVC is defined as "a sequential, three-phase process that involves idea generation, idea development and the diffusion of developed concepts" (Hansen and Birkinshaw, 2007, p.122). Based on Hansen and Birkinshaw's (2007) work, this study builds and expands upon prior studies (e.g. Battisti and Stoneman, 2013; Ganotakis and Love, 2012; Love et al., 2011; Roper et al., 2008) by using innovation survey data to examine how firms develop IVCs. Previous comparative IVC-based community innovation survey (CIS) studies have been conducted, for example, the IVC studies comparing manufacturing firms in France, Germany, Spain and the UK (Griffith et al., 2006), a comparison of Germany and Sweden (Janz et al., 2007) and a study comparing Ireland and Switzerland (Roper and Arvanitis, 2012). However, none of these studies adopts a comparative perspective between developing and developed countries as they all use developed countries as their empirical setting.

4.2.3. Knowledge sourcing activity

In the first link of the IVC, different sources of knowledge from internal and external firms including R&D, informal knowledge and formal cooperation are discussed (Hansen and Birkinshaw, 2007; Roper et al., 2008). The main interest in this link is the relationships, whether synergistic or substitutional, among R&D, informal knowledge and formal cooperation in Indonesian and UK firms. The study of complementarities can be linked to super-modularity theory (Milgrom and Roberts, 1995) that explains how the implementation of one activity increases the marginal returns from another.

4.2.3.1. R&D activities

The first source of knowledge is R&D activity which consists of internal and external R&D. Previous comparative studies in developed economies, including in the UK, reveal that R&D activity is an important source of knowledge and crucial for technological catch-up, innovation and productivity (Autant-Bernard et al., 2010; Battisti et al., 2014; Garcia-Manjon and Romero-Merino, 2012; Griffith et al., 2004; Griffith et al., 2006; Janz et al., 2007; Mohnen et al., 2006; Roper et al., 2010). R&D activity is placed at the centre of innovation by firms in developed economies and the activity is usually performed and financed by the private sector. This differentiates innovation activities in developed economies from those in developing economies (Hobday, 2005). Evidence from the UK confirms that internal R&D is sourced more frequently

than other knowledge (e.g. Doran and O'Leary, 2011; Laursen and Salter, 2004, 2006; Roper et al., 2008). This may suggest that R&D plays a more important role in shaping innovation than other sources of knowledge.

For developing countries, R&D is crucial not only for "pushing back the frontiers of knowledge but also for keeping up with global trends, acquiring knowledge, adapting knowledge to local circumstances, and advancing knowledge" (IBRD, 2010, p.135). It is not surprising that the increase in R&D expenditures in developing countries is faster than in OECD countries and this is influenced by the rapid rise in BRIC countries' expenditures (IBRD, 2010). In the case of Indonesia, public R&D expenditures represent a very small share of GDP and R&D activity is dominated and financed by the government (Aminullah, 2009; Hill and Tandon, 2010; Okamoto and Sjoholm, 2001). The low proportion of R&D expenditure is also present in the manufacturing sector (Madanmohan et al., 2004; Okamoto and Sjoholm, 2001), even in the most R&D intensive sector, the pharmaceutical industry (Okamoto and Sjoholm, 2001). As a result, the country is a net importer of advanced technologies produced by firms in developed economies (Thee, 2005). In addition, the proportion of manufacturing firms that source knowledge from internal R&D is lower than those that source from informal knowledge such as customers (see Chapter 3). Therefore, it is predictable that a greater proportion of UK firms source internal R&D than do Indonesian firms. This supports the study findings that internal R&D is sourced more frequently by manufacturing firms in developed than developing countries (see Chapter 2).

In terms of the relationship between internal and external R&D, most the IVC studies of Ireland and the UK reveal a strong complementary relationship between internal and external R&D (Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). This finding also can be found in the Indonesia IVC study (see Chapter 3) and this may suggest that, in the spirit of open innovation, firms do not rely solely on internal knowledge, but instead complement internal R&D with external knowledge. This finding supports a previous study stating that complementarity between external technology acquisition and internal knowledge development is found in middle-income countries (Hou and Mohnen, 2013).

Apart from IVC studies at the firm level, there is very little insight on the relationship between internal R&D and external knowledge in Indonesia. Previous studies cover broad topics related to R&D, for example, the proportion R&D contributes to the GDP and its impact on technological development (e.g. Okamoto and Sjoholm, 2001); the impact of international R&D transfer on Indonesian manufacturing firms' performance (Jacob and Meister, 2005); informal R&D activities as part of technical efforts in paper industries (Jonker et al., 2006); R&D investment as the internal factor that drives technological capability (Madanmohan et al., 2004); the linkage among R&D, productivity and exports (Yang and Chen, 2012); and the linkage between R&D expenditures and globalisation (Kuncoro, 2012).

4.2.3.2. Informal knowledge

The second group is informal knowledge and consists of nine external actors that can be grouped into *market/commercials* (suppliers, customers, competitors and consultants); *science institutions* (universities, public/government R&D); *associations* (industry associations); and *open sources* (events and scientific publications). The main issue in this link is to what extent differences in the range of informal knowledge contribute to innovation. According to the OECD and Eurostat (2005, p. 79), informal knowledge can be gained from "personal contacts or communities of practice or simply arise in the normal course of business", as well as from any external information sources gained without formal arrangements (Garcia-Torres and Hollanders, 2009). Other scholars (e.g. Freitas et al., 2011) argue that linkages can be classified as informal when actors are sources of information for innovation.

A wide range of external networks have been investigated in previous studies. That range has included *customers* (e.g. Franke and Schreier, 2002; Joshi and Sharma, 2004; Von Hippel and Katz, 2002), *suppliers* (Amara and Landry, 2005; Nieto and Santamaria, 2007; Smith and Tranfield, 2005), *competitors* (e.g. Gnyawali and Jin Park, 2011; Malmberg and Maskell, 2002) and *scientific publications* (e.g. Caloghirou et al., 2004). Apart from the Indonesian IVC study, previous studies also have discussed how different industry sectors and SMEs use traditional and informal knowledge for innovation. In textile industries, technical assistants from foreign trading companies, buyers and inter-firm linkages are used as sources of technological capability (Okamoto and Sjoholm, 2001). In electronic industries, foreign employees, foreign business partners and foreign buyers are treated as important sources of knowledge to support technological capabilities (Gammeltoft, 2004). Competitors have important role as the main external source of knowledge for the Indonesian automotive industry. On the contrary, university and public R&D make small contributions (Aminullah and Adnan, 2012). In Indonesian SMEs, traditional knowledge is gained from learning by doing and experimenting as well as from customers (Van Geenhuizen and Indarti, 2005).

Previous Irish and UK IVC studies involve a range sources of informal knowledge such as customers, suppliers, external consultants, competitors, joint ventures, universities and public research centres (Roper et al., 2008; Roper and Arvanitis, 2012), or source groups that include suppliers, customers, competitors, consultants, universities and government research institutes (Doran and O'Leary, 2011). In Indonesian IVC studies, the list of informal knowledge sources is broader than in UK studies and can be grouped into *market/commercials* (suppliers, customers, competitors, consultant and commercial labs); *science institutions* (universities, polytechnic, government R&D and non-profit R&D); *associations* (investors, industry associations and entrepreneurs); and *open sources* (events, science publication and the internet) (see Chapter 3). Indonesian and UK IVC studies share similar findings. For instance, the synergistic relationship between internal R&D and informal knowledge and among different sources of informal knowledge is present in both countries. In addition, the level of knowledge that is sourced from market/commercials tends to be higher than that sourced from the rest of the external actors.

4.2.3.3. Formal cooperation

The third group of knowledge is formal cooperation and consists of six external agents, excluding external R&D. These agents include firms within the same group, suppliers, competitors, consultants, universities and public/government R&D. Cooperative partners can be in the form of "business organisations such as chambers of commerce, research associations, technology services companies, consultants, universities or public research organisations or the can be sponsored by local, regional or central governments" (OECD and Eurostat, 2005, p. 79).

It is argued that innovation is no longer the province of individual firms, but a matter of collective action with external networks such as customers, suppliers, competitors, consultants and universities (Freel and Harrison, 2006; Tether, 2002). In addition, the relational-based view of the firm suggests that inter-firm relationships can be used as a source of competitive advantage (Dyer and Singh, 1998). Based on this, a range of formal cooperation activities with external actors as sources of knowledge is added in this study, while relatively few previous IVC studies have included formal cooperation (with the exception of Ganotakis and Love, 2012).

A synergistic relationship between internal R&D and formal cooperation was found in both Indonesian and UK firms. Indonesian firms that cooperate with firms in the same group and with suppliers also tend to source knowledge from internal and external R&D. However, these firms source knowledge from scientific institutions less frequently (see Chapter 3). In UK firms, a strong complementary relationship exists between formal cooperation with customers and suppliers and all other forms of knowledge sourcing, except internal R&D (Ganotakis and Love, 2012). Based on this, a hypothesis related to knowledge sourcing links may be proposed:

H1 *In the knowledge sourcing activity, synergistic relationships between internal R&D and external knowledge and among external knowledge sources exist in both Indonesian and UK firms.*

4.2.4. Knowledge transformation activity

In the second link of the IVC, knowledge inputs such as R&D, informal knowledge and formal cooperation, is transformed into innovation outputs and this link represents the innovation or knowledge production function (Griliches, 1992; Love and Roper, 1999). In this link, R&D is included as an input to the IVC and this is different from previous studies that used R&D as a proxy for innovation output (e.g. Griffith et al., 2006). The main interest in this link is the impact of different sources of knowledge input on technological innovation (i.e. product and process), non-technological innovation (i.e. organisational and marketing) and innovation success in both Indonesian and UK firms. Furthermore, the breadth of external knowledge used in shaping innovation is also assessed. Lastly, constraints that may hamper innovation activities are also tested.

4.2.4.1. R&D as the determinant of innovation

R&D is regarded as an important driver of growth because it is intended to generate knowledge to support the growth of business and economic systems as a whole (Garcia-Manjon and Romero-Merino, 2012). Many innovation studies from developed and developing countries consistently report a positive impact of R&D on innovation. In the case of developed economies, R&D positively impacts innovation, productivity and growth (Garcia-Manjon and Romero-Merino, 2012; Griffith et al., 2004; Griffith et al., 2006). A positive association between R&D, innovation and productivity in developing and newly industrialised countries can also be found in Argentina (Chudnovsky et al., 2006), in Malaysia (Hegde and Shapira, 2007), in China (Jefferson et al., 2006) and in Taiwan (Yan Aw et al., 2008). In Indonesia, R&D activity has a positive impact not only on productivity but also on export and this suggests that R&D is an important driver of economic growth for Indonesia (Yang and Chen, 2012).

Previous comparative studies on R&D investment between developed and developing economies (see Chapter 2) and between rich and poor countries (e.g. Goñi and Maloney, 2014) reveal that developed, high-income rich countries invest more in R&D than the developing, middle-income, and poor countries. This, in turn, suggests that R&D is likely to be a more important driver of firm-level innovation in high-income countries like the UK than in middle-income countries such as Indonesia. Previous Irish and UK IVC studies reveal that internal R&D has a consistently positive strong influence on product and process innovation as well as innovation success (Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). The impact of external R&D is restricted to process innovation (Ganotakis and Love, 2012). Surprisingly, Indonesian IVC studies report that internal R&D has a positive and strong impact on both technological and non-technological innovations as well as innovation success. In contrast, external R&D has no significant effect on innovation and innovation success (see Chapter 3). Referring to the comparison between Indonesian and UK firms, a hypothesis related to R&D can be proposed.

H2a The impact of both internal and external R&D on technological and non-technological innovation more strongly and positively impacts UK firms than Indonesian firms.

4.2.4.2. The impact of informal knowledge on innovation

A resource-based view of firms suggests that internal knowledge is an important source of competitive advantage (Barney, 1991). However, few firms possess all the inputs necessary for successful innovation. Therefore, other scholars (e.g. Dyer and Singh, 1998; Zollo and Winter, 2002) extend the resource-based view of the firm that originally focused on the role of internal capabilities by encompassing resources outside firms' boundaries. External knowledge may be gained by using formal modes of external learning such as alliances (e.g. Mowery and Silverman, 1996) and acquisitions (e.g. Ahuja and Katila, 2001) or informal forms that may not be linked to any formal relationship or contract. In this study, informal

knowledge will be linked to external networks such as market/commercials, science institutions, associations and open sources.

Evidence from Indonesian IVC studies shows that different informal links influence different types of innovation (see Chapter 3). For example, customers have strong and positive effects on product innovation, product innovation new to the firms, marketing innovation and innovation success. Competitors have significant influence on product innovation new to the market, process innovation and marketing innovation. The impact of both science institutions such as government and non-profit R&D centres is restrictive of process innovation. From the association group, investors positively impact product innovation new to the firms and process innovation. Lastly, open sources such as events strongly and positively impact product innovation, including new to the market and new to the firm innovations and innovation success. In summary, informal knowledge from the non-science institution group has a stronger and more positive impact on innovation than do science institutions.

Contrary to the IVC studies, different external knowledge also contributes to diverse benefits for the firms. For instance, foreign suppliers play very important roles in shaping technological capability and innovation (Thee, 2005). Foreign buyers also positively influence technical and managerial assistance for Indonesian SMEs (Thee, 2005). Competitors positively impact the development of new products in the Indonesian automotive industry are designed to gain competitive advantage (e.g. Aminullah and Adnan, 2012).

In the case of Irish and UK IVC studies, the impact of informal knowledge on innovation shows different findings. No positive and significant impacts of external knowledge on innovation were found in Doran and O'Leary's (2011) study. Other studies find that only customers and suppliers positively and consistently influence innovation (e.g. Roper et al., 2008; Roper and Arvanitis, 2012). Based on this, another hypothesis may be proposed:

H2b Innovation in Indonesian firms is more strongly and positively impacted by informal knowledge than innovation in UK firms.

4.2.4.3. External knowledge breadth and innovation

The term open innovation indicates that firms cannot innovate in isolation (Dahlander and Gann, 2010) and, therefore, need to engage with external actors to acquire necessary knowledge and resources to compete (Chesbrough, 2003; Laursen and Salter, 2006). Open innovation is indicated by external search breadth and depth (Laursen and Salter, 2006) and has been studied in both developing and developed economies. Empirical evidence shows that open innovation in both developing (e.g. Chiang and Hung, 2010; Kafouros and Forsans, 2012) and developed economies (e.g. Ahn et al., 2014; Battisti et al., 2014; Ebersberger et al., 2012; Laursen and Salter, 2006; Laursen et al., 2007; Salge et al., 2012) has a significant and positive relationship with openness and innovation performance. However, 'over searching' on external

knowledge tends to diminish innovation performance (e.g. Laursen and Salter, 2006; Laursen et al., 2007). Similar findings can also be found in Indonesian IVC studies showing that external breadth strongly, consistently and positively impact innovation and innovation success, while external breadth squared diminishes innovation and innovation success (see Chapter 3).

Following Laursen and Salter (2006), the present study defines external knowledge breadth as the number of external sources that firms use in their innovation process and the impact of external breadth on technological and non-technological innovation are tested. In this study, the total number of informal external knowledge sources is 9. Therefore, if a firm uses all of the external knowledge sources, the total breadth score is 9, and if none are used, the breadth score is 0. Therefore, a hypothesis related to external knowledge breadth can be proposed:

H2c External knowledge breadth has a positive impact on innovation for both Indonesian and UK firms.

4.2.4.4. Formal cooperation and innovation

Strategic management literature has generally agreed that inter-organisational relationships drive a firm's competitive advantage (Dyer and Singh, 1998; Lavie, 2006). At the firm level, cooperation activity in the innovation process plays an important role because such activity is considered an efficient means of facilitating organisation of complex R&D and innovation processes (Faria et al., 2010). Firms need to cooperate since it is difficult for them to innovate on their own (Baptista and Swann, 1998), "fewer firms are able to go it alone in technological development and, as a result, innovation depends increasingly on collective action" (Tether, 2002, p. 947). Previous studies have shown that cooperation activities with other firms provide opportunities such as access to complementary technological resources, faster development of innovations, improved market access and shared cost and risk (e.g. Ahuja, 2000; Cassiman and Veugelers, 2002; Hagedoorn, 2002).

Previous studies on firms' cooperation have discussed determinants of cooperation activities and the impact of cooperation activities on innovation, however, the latter has remained unexplored in both industrial organisational and management literature (Belderbos et al., 2004b). According to Belderbos et al. (2004a), determinants of cooperation can be distinguished by types of cooperation partners. Formal cooperation normally involves management approval and commitments that are documented as memoranda of understanding (MoU) and technical agreements (Hagedoorn, 2002). It is argued that the nature of cooperation partners influences innovation success and firms' overall performance (Faria et al., 2010).

Empirical evidence from UK firms has shown that having a range of cooperation partners positively affects innovation. Using data derived from UK CIS 2, Tether (2002) finds that cooperation with external partners is more likely to be conducted if firms engage in R&D and develop more radical innovations. Cooperation activities with customers and public sector institutions is positively linked to the success of product innovation, while cooperation activities with suppliers and universities significantly influences the

success of process innovation (Freel and Harrison, 2006). Innovative cooperative agreements also play important roles in enhancing UK firms' technological capabilities and vertical links with suppliers and customers are the most important cooperative partners (Iammarino et al., 2012). A UK IVC study also shows that collaboration with customers and suppliers, or supply chain linkages, positively influences innovation (Ganotakis and Love, 2012). Indonesian IVC studies also show similar findings, namely that formal cooperation with suppliers affects innovation and innovation success (see Chapter 3). Therefore, there is a similarity between Indonesian and the UK firms regarding the link between cooperation activities with supply chain linkages and innovation.

4.2.4.5. Innovation barriers and innovation

Innovation barriers are defined as any factors that impede, delay or completely block innovation (Mirow et al., 2008). Examining innovation barriers may be useful for firms in identifying any constraints limiting innovation processes as well as evaluating their impact on the success of innovation. In addition, understanding innovation barriers at the firm level is useful to determine policy priorities for innovation. Comparative, multi-country studies on innovation barriers have been conducted. Using CIS 2 data, Canepa and Stoneman (2002) investigated the importance of financial constraints on innovation for European countries and its differences across industries, countries and firm sizes. Mohnen and Röller (2005) studied complementary relationships among innovation barriers by employing CIS 1 data from Ireland, Denmark, Germany and Italy. Efthyvoulou and Vahter (2012) examined the impact of financial constraints on innovation by firms' sectors and characteristics across eleven European countries. Using European Innovation Survey data (CIS 4 and CIS 2006), Hölzl and Janger (2013) studied the perception of innovation barriers of high growth firms across European countries. The same authors compared the perception of innovation barriers between innovative and non-innovative firms in 18 European countries Hölzl and Janger (2013). A recent study of financial barriers and their impact on productivity across eight European countries was conducted by (Ferrando and Ruggieri, 2015).

Although the aforementioned studies provide important insights on the differences between innovation barriers in various countries, these studies only discuss constraints faced by firms operating in developed economies, more specifically European countries. In addition, there is no empirical evidence of comparative IVC studies that link innovation barriers with innovation. Therefore, the present study attempts to close this gap by linking innovation barriers related to financial, knowledge, market and institutional factors to different types of innovation. A recent study (see Chapter 2) compared innovation barriers experienced by manufacturing firms in developing and developed economies. The findings show that firms in developing economies face more barriers than their counterparts in developed economies. Therefore, it is expected that this effect will be reflected in the results of the second stage of the IVC for Indonesian and UK firms.

There are relatively few IVC studies in the context of developed countries that investigate the impact of innovation barriers on innovation, with the exception of an Irish IVC study conducted by Doran and O'Leary (2011). Irish firms that report a lack of qualified personnel, uncertain demand for innovations and excessive perceived risk are more likely to perform new to the firm innovation. For new to market innovation, firms that face a lack of finances from sources outside their enterprise, uncertain demand for innovative goods or services or a need to meet market regulations are more likely to innovate. This suggests that innovating firms more frequently encounter these constraints than do non-innovating firms (Doran and O'Leary, 2011) and these are defined as 'revealing barriers', meaning that facing these constraints does not prevent innovation, instead, the barriers increase firms' consciousness and knowledge through the experience gained in overcoming the barriers (D'Este et al., 2012). In contrast, Irish firms tend not to perform new to the firm innovation if they experience difficulty in finding cooperative partners. In addition, the Irish firms that report no need to innovate due to an absence of demand for innovations are less likely to develop either new to firm or new to market innovations. These are called 'deterring barriers' and are defined as innovation barriers that reduce the propensity of firms to innovate (D'Este et al., 2012).

In the same vein, Indonesian IVC studies also report both revealing and deterring barriers (see Chapter 3). New to the market and marketing innovators face a greater variety of barriers than other innovators. For example, constraints related to staff and manager resistance do not prevent firms from pursuing new to the market innovation, but lack of external funding, lack of qualified personnel and lack of cooperation make firms less likely to engage in this type of innovation. For marketing innovation, lack of external funding, organisational barriers and lack of cooperation make firms more likely to innovate; while lacking the ability to allocate labour prevents the firms from innovating. Therefore, a hypothesis related to innovation barriers may be proposed:

H2d Indonesian firms face a stronger and a greater variety of innovation barriers than UK firms.

4.2.5. Knowledge exploitation activity

The final link in the IVC is knowledge exploitation that generates value for the firm. In this link, the firm's performance is influenced by innovation (Geroski et al., 1993) as a result of codified knowledge that is gained from the knowledge sourcing activity. The main interest in this link is how firms gain productivity from the exploitation of both technological and non-technological innovations. In this study, productivity, as indicated by total sales and number of employees, is used to measure how innovation affects firms' overall performance. UK and Irish IVC studies find that product and process innovations significantly and positively influence innovation performance (Ganotakis and Love, 2012; Roper et al., 2008). However, innovation success had a negative impact on productivity in Roper's study (e.g. Roper et al., 2008) and no relationship was found (e.g. Ganotakis and Love, 2012). A possible explanation is that short-term disruption effects result from the introduction of new products (Roper et al., 2008).

In the case of Indonesian IVCs, a slightly different finding emerged. Both technological (i.e. process innovation) and non-technological (i.e. organisational innovation) innovation positively and significantly affect productivity. However, findings similar to the Irish and UK IVCs also can be found, with product innovation, new to the market innovation and innovation success having no positive impact on productivity (see Chapter 3). Therefore, a hypothesis can be developed:

H3 In Indonesian firms, both technological and non-technological innovation have positive impacts on productivity, while in UK firms, only technological innovation has a positive impact on productivity.

4.3. Data and Methods

4.3.1. Data

The empirical analysis in this study is based on innovation data derived from the Indonesia Innovation Survey (IIS) 2011 and the UK Innovation Survey (UKIS) 2011. The IIS 2011 data set provides information on the innovation activities of Indonesian manufacturing firms undertaken between 2009 and 2010. The IIS 2011 data is classified based on the International Standard Industrial Classification (ISIC) Rev. 3.1 and a total of 1179 usable observations were found for this study. For international comparison, only firms with 20 or more employees from both innovation data sets are used. The UKIS 2011 provides information on the innovation activities of both UK service and manufacturing firms between 2008 and 2010 and the UK Standard Industrial Classification (UK SIC) 2007 is used to classify the firms. Of 14,342 surveyed firms in the UKIS 2011, the total number of manufacturing firms is 2,849 firms. For the comparison purposes of this study, only manufacturing firms are considered. Of 2849 firms, the total number of manufacturing firms that have 20 or more employees is 2133. Table 4.1 displays the classifications of manufacturing industries used in the IIS 2011 and the UKIS 2011.

Table 4.2 classifies the surveyed firms based on their technology intensity for Indonesia and the UK. For both countries, the greater the technology intensity, the lower the proportion of firms. More than 70% of the Indonesian firms are low-technology firms, and less than 1% are high-technology firms. In addition, the proportional gap among technology intensity classifications is quite high. This profile contrasts to that of UK firms, but the percentage of low-technology firms is still the highest at 33%. However, the proportion gap among technology classification is relatively low, except for high-technology. The UK has a greater proportion of high technology firms than does Indonesia.

Table 4.1 Industry Division: The IIS 2011 and The UKIS 2011

The IIS 2011 (ISIC REV. 3.1)		The UKIS 2011 (UK SIC 2007)	
15	Food & beverages	10	Food products
16	Tobacco products	11	Beverages
17	Textiles	13	Textiles
18	Wearing apparel; dressing and dyeing of fur	14	Wearing apparels
19	Tanning and dressing of leather; Luggage, handbags, saddlery, harness and footwear	15	Leather & related products
20	Wood and of products of wood and cork (except furniture); Articles of straw and plaiting materials	16	Wood & products of wood & cork (except furniture); Articles of straw & plaiting materials
21	Paper and paper products	17	Paper and paper products
22	Printing and publishing	18	Printing & reproduction of recorded media
23	Coke, refined petroleum products, & nuclear fuel	19	Coke & refined petroleum products
24	Chemicals & chemical products	20	Chemicals & chemical products
25	Rubber & plastics products	21	Basic pharmaceutical products & pharmaceutical preparation
26	Other non-metallic mineral products	22	Rubber & plastics products
27	Basic metals	23	Other non-metallic mineral products
28	Fabricated metal products, except machinery & equipment	24	Basic metals
29	Machinery & equipment n.e.c	25	Fabricated metal products, except machinery & equipment
30	Office, accounting & computing machinery	26	Computer, electronic & optical products
31	Electrical machinery & apparatus n.e.c	27	Electrical equipment
32	Radio, TV & communication equipment & apparatus	28	Machinery & equipment n.e.c
33	Medical, precision & optical instruments, watches & clocks	29	Motor vehicles, trailers & semi-trailers
34	Motor vehicles, trailers & semi-trailers	30	Other transport equipment
35	Other transport equipment	31	Furniture
36	Furniture; manufacturing n.e.c.	32	Other manufacturing
37	Recycling	33	Repair & installation of machinery & equipment

Table 4.2 classifies the surveyed firms based on their technology intensity for Indonesia and the UK. It can be observed that for both countries the greater technology intensity, the lower proportion of the firms. More than 70% of the Indonesian firms consist of low-technology firms, by contrast, only less than 1% is high-technology firms. In addition, the proportion gap among technology intensity classification is quite high. Such profile is contrast to the UK firms, despite the percentage of low-technology firms is the highest (around 33%), however, the proportion gap among technology classification is relatively low, except for high-technology. The UK firms have a greater proportion of non-low technology firms than Indonesia firms.

Table 4.2 Technology intensity: The IIS 2011 & The UKIS 2011

Technology intensity classification	The IIS 2011		The UKIS 2011	
	Frequency	%	Frequency	%
Low-technology	866	73.45	703	32.96
Medium-low technology	205	17.39	669	31.36
Medium-high technology	97	8.23	592	27.75
High-technology	11	0.93	169	7.92
Total	1179	100	2133	100

4.3.2. Methods

Variables investigated in this study include firm performance or productivity, innovation performance, innovation output, sources of knowledge, innovation barriers and firm resources (see Appendices 4.1 and 4.2 for variable description and comparison).

4.3.2.1. Knowledge sourcing activity

In this stage, the main issue that is addressed is the behaviour of Indonesian manufacturing firms in sourcing knowledge from various sources. More specifically, synergistic or substitution relationships among the three groups of knowledge are tested. According to Roper et al., (2008), to estimate the simultaneous knowledge sourcing equations (see the equation 1 below), multivariate probit (MVP) would be the most efficient approach. However, the efficiency gains from MVP are reduced where the vectors of independent variable are strongly correlated (Greene, 2005). Beside the issue of similarity of independent variables, the following are difficulties that also arise when adopting MVP practically in using survey-based data (Roper et al., 2008). First, any gains in statistical efficiency by using the simultaneous estimation approach will be offset due to a larger number of missing values. Second, in practice, achieving convergence with an MVP estimator places some limits on the degree of simultaneity which it is possible to include. However, it is undesirable because what is of interest here is the complementary or substitute relationship between knowledge sourcing activities. Third, to derive marginal effects, the usage of simpler modelling frameworks are more straightforward than MVP and this is important to gain a better understanding of the innovation value chain.

Therefore, following Roper et al., (2008), a simple approach of single equation probit model is used to test Hypothesis 1 with the dependent variables being a series of sources of knowledge. This allows for a detailed analysis of the impact of 17 various knowledge sources. Although the approach sacrificing some statistical efficiency, however it provides "substantial gains in terms of the number of observations used, ability to reflect more fully the relationship between knowledge sourcing activities, and ability to identify readily interpretable marginal effects" (Roper at al., 2008, p. 963). The following is the function of the probability that a firm engages in each of the 17 knowledge sourcing activities.

$$KS^*jit = \beta' KSkit + \gamma' RIjit + \varepsilon jit \qquad (1)$$

$$KS\ jit = 1\ if\ KS^*\ jit > 0;\ KS\ jit = 0\ otherwise$$

Where, KSjit stands for the ith firm's knowledge sourcing activity j (or k) at time t, and j, k = 1, 2, 3….17, i = 1,….., n; t=1,…..,T. The error term εjit is assumed to follow a multivariate normal distribution with mean zero and variance-covariance matrix V, where V has values of 1 on the leading diagonal and ρjk = ρkj for j ≠ k. KS kit represents the firm's other knowledge sourcing activities. If β is positive, this would suggest a complementary relationship between the knowledge sourcing activities; negative β would suggest a substitute relationship. RIjit is a set of indicators of the firm's resource.

4.3.2.2. Knowledge transformation activity

In the second IVC link, an innovation or knowledge production function is used to model the knowledge transformation activities (e.g. Geroski, 1990; Harris and Trainor, 1995). Logit regression is used to test Hypotheses 2 with the dependent variables being different types of innovation. Tobit regression is employed when the dependent variable is innovation success (i.e. the proportion of sales derived from product innovation new to the market) that has both upper and lower bounds (0 to 100%). In this study, the innovation or knowledge production function is as follows:

$$INNOV_i = \gamma_0 KS_i + \gamma_1 BREADTH + \gamma_2 INNBAR_i + \gamma_3 RES_i + \varepsilon_i \qquad (2)$$

where INNOV is an innovation output indicator, KS represents knowledge sourcing activity, BREADTH represents the breadth of external knowledge used for innovation (Laursen and Salter, 2006), INNBAR is a set of innovation barriers and other variables are defined in the first equation. In this case, associations between innovation and a set of explanatory variables including knowledge, external knowledge breadth, innovation barriers and firm resources, are positive if γ0, γ1, γ2, γ3 > 0.

4.3.2.3. Knowledge exploitation activity

In the third link of the IVC, OLS regression is used to measure the impact of innovation output on firms' productivity. The equation of the knowledge exploitation activity is as follow:

$$PERFORM_i = x_0 INNOV_i + xi RES_i + \varepsilon_i \qquad (3)$$

where PERFORM is an indicator of firm performance, INNOV is innovation output that consists of product, process, organisation, and marketing innovation. In this case, association between firm productivity and a range of innovation output is positive if $x0 > 0$.

4.4. Results

4.4.1. Descriptive statistics

Table 4.3 reports descriptive statistics for the major variables in this study. Of three groups of sources of knowledge, the average proportion of UK firms that source knowledge from internal R&D is greater than the proportion of those that used all other sources of knowledge (35.60%). In contrast, knowledge from external agents such as universities, public R&D, government R&D and scientific publication is the lowest, each accounting for only1.60%. For Indonesia, the highest proportion of knowledge is sourced from customers (34.40%) and the lowest is formal cooperation with public and government R&D (0.80%).

Table 4.3 clearly shows that the proportion of UK firms that source knowledge from R&D activities, both internal and external, and formal cooperation is higher than for Indonesian firms. The proportion of Indonesian firms that source knowledge from informal knowledge providers is greater than for UK firms. Despite that Indonesian firms face more innovation barriers than UK firms, surprisingly, Indonesian firms produce more innovation outputs (except for organisational innovation) and experience more innovation success than UK firms. These descriptive statistics thus lend some initial support for Hypotheses 2a, 2b and 2c. A comparison of firm resources shows that UK firms have a greater average number of employees, higher education levels and a higher proportion of exporters than Indonesian firms. This again suggests that Indonesian firms tend to have fewer internal resources than their UK counterparts, perhaps partly explaining their tendency to compensate for this with a greater use of informal knowledge sourcing than UK firms. In terms of technology intensity, both data sets show that the greater the level of technology intensity, the lower proportion of firms. The UK has a greater proportion of high technology firms than does Indonesia.

Table 4.3 Descriptive Statistics: The IIS 2011 and The UKIS 2011

VARIABLES	IIS 2011			UKIS 2011		
	OBS	MEAN	SD	OBS	MEAN	SD
Firm performance						
PRODUCTIVITY	1179	**1312.096**	8399.761	1470	**143.01**	155.43
Innovation performance						
INNSUCCESS (%)	1179	**8.429**	16.985	1295	**3.351**	8.509
Types of innovation						
PRODINOV (0/1)	1179	**.377**	.485	2133	**.372**	.484
PRODINOV_NEW2MARKET (0/1)	1179	**.288**	.453	2133	**.199**	.400
PRODINOV_NEW2FIRM (0/1)	1179	**.358**	.480	2133	**.266**	.442
PROCINOV (0/1)	1179	**.322**	.468	2133	**.238**	.426
ORGINN (0/1)	1179	**.310**	.463	2133	**.371**	.483
MKTGINN (0/1)	1179	**.428**	.495	2133	**.181**	.385
R&D activities						
INTERNAL_RD (0/1)	1179	**.292**	.455	2133	**.356**	.479
EXTERNAL_RD (0/1)	1179	**.032**	.177	2133	**.146**	.353
Market agents						
SUPPLIERS (0/1)	1196	**.188**	.391	2078	**.153**	.360
CUSTOMERS (0/1)	1188	**.344**	.475	2078	**.289**	.454
COMPETITORS (0/1)	1179	**.225**	.418	2080	**.103**	.305
CONSULTANTS (0/1)	1196	**.079**	.269	2080	**.042**	.200
Science institutions						
UNIVERSITIES (0/1)	1196	**.059**	.235	2079	**.016**	.127
GOV_RD (0/1)	1179	**.041**	.198	2079	**.016**	.127
Associations						
INDUSTRY_ASSOC (0/1)	1179	**.065**	.247	2079	**.033**	.179
Open sources						
EVENTS (0/1)	1188	**.109**	.312	2079	**.037**	.188
SCIENCE_PUB (0/1)	1188	**.067**	.251	2077	**.016**	.127
Formal cooperation						
COOP_FIRMGROUP (0/1)	1179	**.026**	.160	2133	**.188**	.390
COOP_SUPPLIERS (0/1)	1179	**.048**	.215	2133	**.245**	.430
COOP_COMPETITORS (0/1)	1179	**.012**	.108	2133	**.083**	.275
COOP_CONSULTANTS (0/1)	1196	**.033**	.178	2133	**.131**	.338
COOP_UNIVERSITIES (0/1)	1179	**.013**	.112	2133	**.100**	.301
COOP_GOVRD (0/1)	1179	**.008**	.087	2133	**.061**	.240
Financial barriers						
INBAR_HIGHRISK (0/1)	1196	**.256**	.437	-	-	-
INBAR_HIGHCOST (0/1)	1196	**.268**	.443	2133	**.120**	.325
INBAR_INFUND (0/1)	1196	**.268**	.443	-	-	-
INBAR_EXFUND (0/1)	1196	**.262**	.440	-	-	-
INBAR_ECON RISK (0/1)	-	-	-	2133	**.116**	.321
INBAR_COSTFIN (0/1)	-	-	-	2133	**.105**	.306
INBAR_COSTAVAILABLE	-	-	-	2133	**.112**	.315
Knowledge barriers						
INBAR_PERSON (0/1)	1196	**.176**	.381	2133	**.046**	.209
INBAR_TECHINFO (0/1)	1196	**.160**	.366	2133	**.020**	.139
INBAR_MARKETINFO (0/1)	1196	**.130**	.336	2133	**.020**	.141

Market barriers						
INBAR_MKTDOM (0/1)	1196	**.218**	.413	2133	**.059**	.235
INBAR_UNCERDEM (0/1)	1196	**.177**	.382	2133	**.068**	.253
Institution barriers						
INBAR_GOVREG (0/1)	1196	**.138**	.345	2133	**.043**	.203
Firm resources						
EMPLOYMENT	1179	**174.608**	1318.078	2133	**240.952**	487.333
EXPORTERS (0/1)	1196	**.202**	.402	2114	**.472**	.264
UNDERGRAD (%)	1179	**4.077**	8.623	-	-	-
SCIENCE_DEGREE (%)	-	-	-	1448	**5.939**	10.300
OTHER_DEGREE (%)	-	-	-	1437	**5.140**	9.404
LOW-TECH (0/1)	1179	**.735**	.442	2133	**.330**	.470
MEDLOW-TECH (0/1)	1179	**.174**	.379	2133	**.314**	.464
MEDHIGH-TECH (0/1)	1179	**.082**	.275	2133	**.278**	.448
HIGH-TECH (0/1)	1179	**.009**	.096	2133	**.079**	.270

4.4.2. Knowledge sourcing activity

Comparative analysis of the first link of IVC between Indonesian and UK firms is divided into three groups source of knowledge such as R&D activities, informal knowledge and formal cooperation. Table 4.4 represents knowledge sourcing activities performed by Indonesia firms with R&D activities and informal knowledge as the independent variables, and similar activities conducted by UK firms are displayed in Table 4.5. Formal cooperation as the independent variable for both Indonesian and UK firms is displayed in Tables 4.6 and 4.7, respectively.

4.4.2.1. R&D activities

Tables 4.4 and 4.5 show a strong synergistic or complementary relationship between internal and external R&D and this may indicate that manufacturing firms in both countries are more likely to generate their own knowledge from internal R&D if they also participate in external R&D. This finding confirms previous IVC studies (Battisti and Stoneman, 2013; Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). Such relationships also exist between internal R&D and market/commercials networks in both datasets. In the case of Indonesian firms, there is no evidence of substitution strategy between internal R&D and external knowledge. This suggests that firms adopt open innovation strategies to compensate for resources that might be lacking compared to the resources of UK firms. The two datasets also show different patterns in knowledge sourcing activities. In terms of external R&D, there is no indication of a synergistic relationship between external R&D and any external sources of knowledge used by Indonesian firms. In UK firms, external R&D also tends to be sourced in combination with market/commercials such as customers and consultants. In addition, exporters and medium to high-technology firms in the UK have a positive association with internal R&D, while such association does not exist in Indonesia. This suggests that exporters need advanced knowledge gained from internal R&D to be competitive in international markets.

4.4.2.2. Informal knowledge

Based on Tables 4.4 and 4.5, both data sets display synergistic relationships among market/commercials; between market/commercials and associations; and between market/commercials and open sources. Furthermore, the firms in both countries that source knowledge from science institutions also tend to source knowledge from consultants. In terms of technology intensity, high technology UK firms tend to source knowledge from science institutions such as universities, however, there is no clear pattern in the relationship between technology intensity and sources of knowledge in Indonesian firms. This suggests that the higher the level of technology intensity of firms, the more advanced the types of external knowledge sourced.

Table 4.4 Knowledge sourcing activity – The IIS 2011: (IV: R&D and Informal knowledge)

INDEPENDENT VARIABLES	Model 1 INTERNAL_RD	Model 2 EXTERNAL_RD	Model 3 SUPPLIERS	Model 4 CUSTOMERS	Model 5 COMPETITORS	Model 6 CONSULTANTS
INTERNAL_RD	-	**.089*** (.017)**	-.013 (.028)	**.119*** (.025)**	**.049** (.022)**	**.051*** (.014)**
EXTERNAL_RD[5]	**.613*** (.099)**	-	.009 (.066)	-.007 (.062)	.024 (.050)	.026 (.025)
Market/commercials						
SUPPLIERS	-.016 (.031)	.003 (.013)	-	.036 (.028)	-.005 (.026)	.011 (.016)
CUSTOMERS	**.144*** (.028)**	.002 (.011)	.040 (.029)	-	**.292*** (.017)**	-.006 (.015)
COMPETITORS	**.052* (.031)**	.005 (.011)	-.004 (.032)	**.358*** (.022)**	-	**.037** (.015)**
CONSULTANTS	**.168*** (.050)**	.016 (.015)	.034 (.050)	-.056 (.051)	**.086** (.039)**	-
Science institutions						
UNIVERSITIES	.108 (.066)	.006 (.018)	.022 (.063)	-.035 (.064)	.033 (.049)	**.076*** (.021)**
GOV_RD	.035 (.068)	-.010 (.021)	.005 (.068)	.039 (.067)	-.052 (.052)	**.065*** (.023)**
Associations						
IND_ASSOC.	**.146*** (.050)**	-.010 (.017)	-.025 (.052)	**.104* (.054)**	.011 (.040)	**.046** (.019)**
Open sources						
EVENTS	.065 (.043)	.001 (.015)	.044 (.042)	**.239*** (.044)**	**.077** (.032)**	.005 (.018)
SCIENCE_PUB	-.054 (.053)	.005 (.017)	-.060 (.053)	**.216*** (.059)**	.040 (.039)	**.047** (.020)**
Firm resources						
EMPLOYMENT	-.00002 (.00003)	-.00002 (.00003)	.000002 (.00001)	-.000005 (.00001)	-.00004 (.00003)	-.00003 (.00004)
EXPORTERS	-.0001 (.0005)	.00004 (.0002)	**.001** (.0004)**	.0004 (.0004)	.00002 (.0004)	.0004 (.0002)
UNDERGRAD	-	-	-	-	-	-
LOW_TECH	-	-	-	-	-	-
MEDLOW_TECH	**-.069** (.034)**	.010 (.013)	.038 (.030)	.031 (.029)	-.032 (.028)	**.033** (.016)**
MEDHIGH_TECH	.027 (.042)	-.038 (.028)	.019 (.041)	.040 (.040)	-.047 (.038)	-.003 (.025)
HIGH_TECH	-.092 (.136)	-	-.025 (.115)	.177 (.115)	-.138 (.114)	-

[5]External R&D in this study is grouped in R&D activities along with internal R&D, however, based on the degree of externalisation, external R&D, informal and open networks, and cooperation activities 'are external to the enterprise to various degrees, depending on their ownership and the contractual structures of the relationship between our enterprise and the other party or parties to the transfer' (Frenz and Ietto-Gillies, 2009, p. 1126).

Observations	1179	1168	1179	1179	1179	1168
LR chi2 ( )	214.21	84.74	30.27	438.44	339.08	154.78
Prob. > chi2	.000	.000	.0349	.000	.000	.000
Pseudo R2	.151	.253	.0263	.288	.2699	.2727
Log likelihood	-604.70	-125.17	-559.56	-541.84	-458.72	-206.40
Mean VIF	4.99	5.00	5.00	4.96	4.97	4.98

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

Table 4.4 Knowledge sourcing activity – The IIS 2011: (IV: R&D and Informal knowledge) *(continued)*

INDEPENDENT VARIABLES	Model 7 UNIVERSITIES	Model 8 GOV_RD	Model 9 IND_ASSOC	Model 10 EVENTS	Model 11 SCIENCE_PUB
INTERNAL_RD	**.024**(.011)**	.012(.010)	**.047***(.013)**	**.032**(.016)**	-.001(.013)
EXTERNAL_RD	.014(.018)	.0001(.019)	-.003(.026)	.013(.032)	.018(.024)
Market/commercials					
SUPPLIERS	.004(.012)	.003(.012)	-.009(.016)	.017(.018)	-.018(.015)
CUSTOMERS	.002(.012)	.016(.011)	**.031**(.015)**	**.103***(.018)**	**.070***(.016)**
COMPETITORS	.013(.011)	-.005(.011)	.017(.014)	**.042***(.016)**	.019(.013)
CONSULTANTS	**.044***(.013)**	**.032***(.012)**	**.039**(.018)**	.011(.025)	**.043**(.017)**
Science institutions					
UNIVERSITIES	-	**.070***(.012)**	**.045**(.020)**	.018(.029)	.031(.020)
GOV_RD	**.081***(.014)**	-	**.060***(.021)**	**.048*(.028)**	.023(.020)
Associations					
IND_ASSOC.	**.031**(.013)**	**.035***(.012)**	-	**.079***(.022)**	.022(.017)
Open sources					
EVENTS	.007(.013)	**.019*(.012)**	**.031*(.018)**	-	**.094***(.012)**
SCIENCE_PUB	.023(.014)	.01 (.013)	**.056***(.016)**	**.146***(.019)**	-
Firm resources					
EMPLOYMENT	-.00004(.00004)	.000001(.000004)	-.000003(.00002)	.000002(.00001)	-.000003(.00002)
EXPORTERS	-.0002(.0002)	-.00002(.0002)	.0002(.0002)	-.0002(.0003)	-.0002(.0002)
UNDERGRAD	-	-	-	-	-
LOW_TECH	-	-	-	-	-

MEDLOW_TECH	-.020(.016)	-.022(.016)	.011(.017)	-.021(.021)	-.013(.018)
MEDHIGH_TECH	.005(.017)	-.006(.017)	**.051*** (.019)**	-.032(.028)	.021(.019)
HIGH_TECH	.001(.045)	.044(.030)	.041(.052)	.074(.057)	-
Observations	1179	1179	1179	1179	1168
LR chi2 ( )	165.70	160.40	175.36	296.72	236.99
Prob. > chi2	.000	.000	.000	.000	.000
Pseudo R2	.3832	.400	.3081	.3626	.4062
Log likelihood	-133.35	-120.47	-196.86	-260.83	-173.18
Mean VIF	4.97	4.97	4.98	4.97	4.97

Notes: ***p<0.001, **p<0.05, *p<0.10. All figures in the tables are marginal effects generated from probit models.

Table 4.5 Knowledge sourcing activity – The UKIS 2011: (IV: R&D and Informal knowledge)

INDEPENDENT VARIABLES	Model 1 INTERNAL_RD	Model 2 EXTERNAL_RD	Model 3 SUPPLIERS	Model 4 CUSTOMERS	Model 5 COMPETITORS	Model 6 CONSULTANTS
INTERNAL_RD	-	**.287*** (.023)**	**.081*** (.025)**	**.233*** (.023)**	**.051** (.021)**	.011(.015)
EXTERNAL_RD	**.370*** (.030)**	-	.021(.026)	.031(.029)	.002(.019)	**.035*** (.013)**
Market/Commercials						
SUPPLIERS	**.073** (.029)**	.023 (.023)	-	**.182*** (.026)**	**.040** (.018)**	**.064*** (.013)**
CUSTOMERS	**.231*** (.023)**	**.040* (.022)**	**.162*** (.022)**	-	**.171*** (.018)**	-.006(.014)
COMPETITORS	.058(.038)	-.008(.028)	**.060** (.029)**	**.314*** (.034)**	-	**.029** (.015)**
CONSULANTS	.035(.058)	**.090** (.038)**	**.210*** (.040)**	-.034(.054)	**.056* (.030)**	-
Science institutions						
UNIVERSITIES	.169(.118)	.057 (.062)	-.015(.069)	**.160* (.095)**	-.002(.048)	**.102*** (.025)**
GOV_RD	-.129(.090)	**-.128* (.066)**	.063(.068)	.081(.099)	.056(.046)	**.060** (.026)**
Associations						
IND_ASSOC.	-.051(.067)	.024(.046)	**.112** (.048)**	**.215*** (.075)**	**.081** (.032)**	.004(.022)
Open sources						
EVENTS	-.004(.059)	.030(.042)	-.001(.046)	**.135** (.062)**	**.106*** (.030)**	**.040** (.020)**
SCIENCE_PUB	**.200* (.116)**	.080(.058)	.035(.065)	-.045(.095)	.064(.044)	.002(.028)
Firm resources						

EMPLOYMENT	.00002(.00003)	**.0001***(.00002)**	-.001(.00003)	**.0001**(.00003)**	.00003(.00002)	.00001(.00001)
EXPORTERS	**.107***(.024)**	.012(.023)	-.019(.024)	.004(.025)	.014(.020)	-.013(.013)
EDU_SCIENCE	**.004***(.001)**	.001 (.001)	-.0002(.001)	.001(.001)	.0005(.001)	**.001**(.0005)**
EDU_OTHERS	.001(.001)	**.002**(.001)**	-.001(.001)	.0002(.001)	.001*(.001)	.0005(.001)
LOW_TECH	-	-	-	-	-	-
MEDLOW_TECH	**-.064**(.028)**	.020(.026)	-.031(.028)	.042(.028)	-.033(.021)	-.003(.015)
MEDHIGH_TECH	**.059*(.031)**	.019(.026)	**-.054*(.028)**	.030(.030)	.023(.023)	.021(.016)
HIGH_TECH	.057(.050)	.06 (.041)	**-.095**(.038)**	.064(.048)	.021(.035)	-.002(.021)
Observations	1371	1371	1371	1371	1371	1371
LR chi2 ( )	518.29	331.15	201.88	472.59	325.95	158.61
Prob. > chi2	.000	.000	.000	.000	.000	.000
Pseudo R2	.273	.228	.138	.254	.281	.251
Log likelihood	-688.65	-559.82	-631.91	-695.46	-417.17	-236.64
Mean VIF	1.64	1.65	1.66	1.64	1.65	1.66

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

Table 4.5 Knowledge sourcing activity – The UKIS 2011: (IV: R&D and Informal knowledge) *(continued)*

INDEPENDENT VARIABLES	Model 7 UNIVERSITIES	Model 8 GOV_RD	Model 9 IND_ASSOC	Model 10 EVENTS	Model 11 SCIENCE_PUB
INTERNAL_RD	.015(.011)	-.005(.009)	.001(.013)	.011(.013)	**.020***(.012)
EXTERNAL_RD	.008(.008)	-.009(.009)	.012(.011)	.007(.012)	.012(.008)
Market/Commercials					
SUPPLIERS	.004(.008)	.007(.008)	**.028***(.010)**	.003(.012)	.007(.008)
CUSTOMERS	**.016*(.009)**	.008(.009)	**.037***(.013)**	**.033**(.013)**	.0002(.009)
COMPETITORS	-.0002 (.008)	.011(.008)	**.030***(.011)**	**.044***(.013)**	**.014*(.008)**
CONSULANTS	**.033***(.009)**	**.023**(.010)**	.007(.015)	.032(.017)	-.003(.011)
Science institutions					
UNIVERSITIES	-	**.038***(.013)**	.023(.023)	-.019(.028)	.016(.016)
GOV_RD	**.041***(.012)**	-	**.065***(.019)**	**.049**(.024)**	-.006(.016)
Associations					

INDUSTRY_ASSOC.	.010(.011)	**.033***(.010)**	-	**.067***(.016)**	**.032***(.009)**
Open resources					
EVENTS	.0002(.011)	**.018*(.010)**	**.056***(.013)**	-	**.040***(.009)**
SCIENCE_PUB	.011(.015)	-.021(.016)	**.062***(.017)**	**.088***(.020)**	-
Firm resources					
EMPLOYMENT	-.000004(.00001)	.000002(.00001)	.00001(.00001)	-.00001(.00001)	.000004(.00001)
EXPORTERS	.007(.011)	.003(.009)	-.001 (.012)	**.024*(.014)**	.010(.010)
EDU_SCIENCE	-.0005(.0003)	**.001***(.0002)**	-.0001 (.0005)	**-.002**(.001)**	.0004(.0003)
EDU_OTHER	.0003(.0003)	-.0001(.0003)	**.001*(.0004)**	.001 (.0004)	-.00003(.0004)
LOW_TECH	-	-	-	-	-
MEDLOW_TECH	**.016**(.008)**	.008(.011)	.004(.014)	-.017(.014)	-.004(.011)
MEDHIGH_TECH	**.024***(.008)**	-.006(.009)	-.001(.013)	.0002(.015)	-.010(.010)
HIGH_TECH	**.041**(.017)**	.007(.014)	-.002(.018)	-.029(.018)	-.009(.013)
Observations	1371	1371	1371	1371	1371
LR chi2 ( )	109.46	110.20	198.73	176.84	116.95
Prob. > chi2	.000	.000	.000	.000	.000
Pseudo R2	.370	.363	.367	.304	.367
Log likelihood	-93.38	-96.77	-171.18	-202.42	-100.80
Mean VIF	1.66	1.66	1.65	1.65	1.66

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

4.4.2.3. Formal cooperation

Tables 4.6 and 4.7 show that formal cooperation clearly distinguishes how Indonesian and UK firms perform knowledge sourcing activity. In Indonesia, firms that cooperate with other firms in the same group and suppliers are more likely to generate knowledge from internal and external R&D. In addition, firms that cooperate with firms in the same group also tend to interact with non-science institutions. This may indicate that sourcing knowledge from R&D activities do not lead the firms to interact with science institutions. In summary, strong synergistic relationships exist between firm groups and internal R&D; between firm groups and external R&D; between firm groups and non-science institutions; between suppliers and internal R&D; and between suppliers and external R&D.

In contrast, UK firms that source knowledge from formal cooperation also tend to source knowledge from internal and external R&D, except firms that cooperate with public or government R&D. These firms also tend to source knowledge from non-scientific agents. In summary, in terms of formal cooperation, the synergistic relationships in UK firms involve wider formal cooperation partners than in Indonesian firms.

Turning to control variables, the two data sets show different relationships between employment and sources of knowledge, with negative relationships found in Indonesian firms and significant positive relationships found for UK firms. Indonesian exporters tend to source knowledge from consultants, while the UK exporters are more likely source from diverse knowledge providers such as internal R&D, competitors, events and science publications. This may suggest that entering and competing in overseas markets requires UK firms to do more formal cooperating and source knowledge from more diverse knowledge providers. Both datasets show positive relationships between employee quality and sources of knowledge. In terms of technology intensity, the UKIS 2011 data set shows that the greater the technology intensity of the firms, the more likely the firms are to source knowledge from internal R&D and science institution such as universities. However, there is no clear pattern found in the IIS 2011 data set.

Based on the findings from the knowledge sourcing link, there is clear support for Hypothesis 1. For both countries, synergistic relationships exist within each knowledge source group, including R&D, informal knowledge and formal cooperation. However, the nature of these complementarities differs between the two countries.

Table 4.6 Knowledge sourcing activity – The IIS 2011: (IV: Formal cooperation)

INDEPENDENT VARIABLES	Model 1 INTERNAL_RD	Model 2 EXTERNAL_RD	Model 3 SUPPLIERS	Model 4 CUSTOMERS	Model 5 COMPETITORS	Model 6 CONSULTANTS
COOP_FIRMGROUP	**.532*** (.128)**	**.055*** (.015)**	-.053 (.085)	**.197** (.099)**	.107 (.082)	**.097*** (.036)**
COOP_SUPPLIERS	**.267*** (.074)**	**.075*** (.014)**	.059 (.065)	.105 (.078)	.051 (.066)	.017 (.033)
COOP_COMPET.	.282 (.195)	-.010 (.021)	.033 (.119)	.103 (.146)	**.244** (.120)**	-.026 (.058)
COOP_CONSUL.	.015 (.130)	-.013 (.021)	-.039 (.105)	-.026 (.124)	-.015 (.104)	**.095** (.045)**
COOP_UNIV.	.187 (.160)	.020 (.024)	.032 (.122)	-.061 (.151)	.009 (.129)	.034 (.058)
COOP_GOVRD	-	.031 (.026)	.090 (.151)	-.0004 (.185)	.103 (.152)	.022 (.075)
Firm resources						
EMPLOYMENT	-.00005 (.00004)	-.00002 (.00003)	.0000001 (.00001)	-.00002 (.00002)	-.00004 (.00004)	-.00004 (.00004)
EXPORTERS	.003 (.032)	-.001 (.011)	.041 (.028)	.027 (.035)	.012 (.031)	**.028* (.017)**
UNDERGRAD	.00003 (.001)	.00003 (.001)	**.003** (.001)**	.002 (.002)	.002 (.001)	-.00001 (.001)
LOW_TECH	-	-	-	-	-	-
MEDLOW_TECH	**-.078** (.031)**	-.006 (.011)	.041 (.032)	-.019 (.036)	**-.050* (.031)**	.010 (.019)
MEDHIGH_TECH	.025 (.049)	**-.027*** (.009)**	.025 (.043)	.036 (.052)	-.036 (.043)	-.009 (.024)
HIGH_TECH	-.0003 (.133)	-	-.004 (.114)	.201 (.150)	-.060 (.114)	-
Observations	1170	1168	1179	1179	1179	1168
LR chi2 ( )	.000	.000	.585	.113	.027	.000
Prob. > chi2	.064	.344	.009	.012	.018	.069
Pseudo R2	-656.12	-109.84	-569.49	-752.00	-616.71	-264.19
Log likelihood	1.52	1.53	1.53	1.53	1.53	1.53
Mean VIF	89.01	115.42	10.39	18.1	23.1	39.19

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

Table 4.6 Knowledge sourcing activity – The IIS 2011 *(continued)*

INDEPENDENT VARIABLES	Model 7 UNIVERSITIES	Model 8 GOV_RD	Model 9 IND_ASSOC	Model 10 EVENTS	Model 11 SCIENCE_PUB
COOP_FIRMGROUP	.044 (.038)	.052 (.037)	**.090**** **(.040)**	**.105*** **(.055)**	**.116**** **(.046)**
COOP_SUPPLIER	.001 (.033)	-.010 (.033)	.013 (.036)	.037 (.047)	.024 (.040)
COOP_COMPET.	.019 (.055)	-	.075 (.058)	-.130 (.105)	-
COOP_CONSUL.	**-.151**** **(.075)**	-.063 (.074)	-.031 (.057)	.014 (.072)	-.007 (.069)
COOP_UNIV.	**.166***** **(.047)**	.009 (.070)	.032 (.066)	.132 (.084)	-
COOP_GOVRD	-.002 (.061)	**.123*** **(.075)**	-.031 (.084)	-.033 (.117)	-
Firm resources					
EMPLOYMENT	-.00002 (.00003)	-.000001 (.00001)	-.00001 (.00002)	-.000003 (.00001)	-.00001 (.00002)
EXPORTERS	.019 (.014)	.003 (.015)	.007 (.018)	-.011 (.024)	.002 (.019)
UNDERGRAD	-.001 (.001)	.00003 (.001)	-.0003 (.001)	-.001 (.001)	.001 (.001)
LOW_TECH	-	-	-	-	-
MEDLOW_TECH	**-.025*** **(.013)**	**-.024**** **(.012)**	-.004 (.018)	**-.040*** **(.022)**	**-.032*** **(.017)**
MEDHIGH_TECH	-.011 (.021)	-.013 (.019)	.053 (.033)	-.029 (.031)	.003 (.029)
HIGH_TECH	.057 (.095)	.140 (.117)	.136 (.121)	.168 (.137)	-
Observation	1179	1165	1179	1179	1141
LR chi2 ( )	.011	.182	.142	.075	.042
Prob. > chi2	.060	.038	.030	.024	.028
Pseudo R2	-203.22	-192.58	-275.924	-399.40	-281.73
Log likelihood	1.53	1.53	1.53	1.53	1.53
Mean VIF	25.97	15.01	17.22	19.58	16.02

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

Table 4.7 Knowledge sourcing activity – The UKIS 2011

INDEPENDENT VARIABLES	Model 1 INTERNAL_RD	Model 2 EXTERNAL_RD	Model 3 SUPPLIERS	Model 4 CUSTOMERS	Model 5 COMPETITORS	Model 6 CONSULTANTS
COOP_FIRMGROUP	**.082***(.031)**	**.056**(.023)**	.005 (.027)	**.120***(.031)**	**.043*(.022)**	-.007 (.015)
COOP_SUPPLIER	**.213***(.027)**	**.108***(.022)**	**.243***(.023)**	**.191***(.028)**	**.043**(.021)**	.006 (.015)
COOP_COMPET.	.058 (.044)	.007 (.030)	-.001 (.034)	.065 (.042)	**.084***(.026)**	.009 (.017)
COOP_CONSUL.	**.191***(.038)**	**.165***(.024)**	**.060**(.030)**	**.080**(.037)**	**.060**(.024)**	**.111***(.016)**
COOP_UNIV.	**.165***(.044)**	**.108***(.027)**	-.012 (.034)	**.072*(.041)**	-.002 (.027)	-.014 (.017)
COOP_GOVRD	**-.140**(.055)**	**-.096***(.035)**	-.016 (.041)	-.059 (.052)	.010 (.032)	.012 (.018)
Firm resources						
EMPLOYMENT	**.0001*(.00003)**	**.0001***(.00002)**	-.00001 (.00003)	**.0001**(.00003)**	**.00004**(.00002)**	.00001 (.00001)
EXPORTERS	**.102***(.025)**	.028 (.022)	-.018 (.024)	.030 (.028)	**.037*(.022)**	-.014 (.014)
EDU_SCIENCE	**.004***(.001)**	.001 (.001)	.001 (.001)	.002 (.001)	.001 (.001)	**.001***(.0005)**
EDU_OTHER	**.002*(.001)**	**.002**(.001)**	-.0003 (.001)	.001 (.001)	**.002**(.001)**	-.0003 (.001)
LOW_TECH	-	-	-	-	-	-
MEDLOW_TECH	**-.055*(.029)**	.003 (.024)	-.024 (.028)	.019 (.031)	**-.043*(.022)**	-.004 (.015)
MEDHIGH_TECH	**.076**(.031)**	.032 (.025)	-.026 (.029)	.053 (.033)	.035 (.025)	.025 (.017)
HIGH_TECH	**.101**(.051)**	.096 (.042)	-.054 (.042)	.081 (.052)	.037 (.039)	.012 (.024)
Observations	1428	1428	1373	1373	1375	1375
LR chi2 ( )	425.34	306.20	163.47	240.35	142.4	129.22
Prob. > chi2	.000	.000	.000	.000	.000	.000
Pseudo R2	.215	.207	.112	.129	.123	.204
Log likelihood	-776.91	-586.253	-651.63	-812.67	-509.59	-251.583
Mean VIF	1.89	1.89	1.37	1.37	1.37	1.87

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

Table 4.7 Knowledge sourcing activity – The UKIS 2011 *(continued)*

INDEPENDENT VARIABLES	Model 7 UNIVERSITIES	Model 8 GOV_RD	Model 9 IND_ASSOC	Model 10 EVENTS	Model 11 SCIENCE_PUB
COOP_FIRMGROUP	**-.020**(.010)**	.013 (.010)	**.043***(.014)**	**.040***(.015)**	.013(.010)
COOP_SUPPLIERS	.013 (.010)	-.0005 (.010)	-.012(.014)	-.00 (.015)	.002(.010)
COOP_COMPETITORS	**.017*(.009)**	-.005 (.010)	**.035**(.015)**	.023 (.017)	**.024**(.011)**
COOP_CONSULTANTS	-.003 (.009)	.009 (.010)	**.025*(.015)**	**.031*(.016)**	**.023**(.010)**
COOP_UNIVERSITIES	**.055***(.011)**	-.013 (.010)	.002(.016)	.018(.017)	.007(.011)
COOP_GOVRD	.005 (.009)	**.053***(.012)**	.028(.017)	-.029(.022)	-.016(.013)
Firm resources					
EMPLOYMENT	-.000004(.00001)	.000001(.00001)	.00001(.00001)	.00001(.00001)	.00001(.00001)
EXPORTERS	.015(.012)	.001(.010)	.009(.014)	**.034**(.016)**	**.020*(.012)**
EDU_SCIENCE	.0001(.0003)	**.001***(.0002)**	.0003(.0005)	-.0003 (.001)	**.001*(.0003)**
EDU_OTHER	.00001(.0003)	-.0002(.0004)	**.001*(.0004**	.001(.001)	.0001(.0004)
LOW-TECH	-	-	-	-	-
MEDLOW-TECH	.012 (.007)	.005 (.010)	-.008 (.015)	-.024 (.016)	-.012 (.012)
MEDHIGH-TECH	**.025***(.008)**	.001 (.010)	.001 (.015)	.006 (.018)	-.005 (.012)
HIGH-TECH	**.041**(.016)**	.008 (.014)	-.001 (.021)	-.024 (.021)	-.010 (.015)
Observation	1374	1374	1374	1374	1372
LR chi2 ()	113.62	81.73	83.39	50.03	49.06
Prob. > chi2	.000	.000	.000	.000	.000
Pseudo R2	.3834	.269	.154	.086	.154
Log likelihood	-91.38	-111.07	-229.00	-266	-134.77
Mean VIF	1.87	1.87	1.87	1.87	1.37

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the tables are marginal effects generated from probit models.

4.4.3. Knowledge transformation activity

The second link in the IVC is knowledge transformation and is divided into technological and non-technological innovation represented by the innovation production function (Equation 2). The interest in this link is the contribution of each knowledge source to innovation, innovation success and other factors contributing to the firms' transformation activity. Tables 4.8 and 4.9 display the second link of the IVC for Indonesian and UK manufacturing firms, respectively.

4.4.3.1. R&D activities

Tables 4.8 and 4.9 show that internal R&D positively and significantly affects innovation and innovation success. Of the different sources of knowledge, internal R&D has the strongest and most consistent positive impact on innovation and innovation success in the IVC models for both Indonesia and the UK. This confirms the results of the majority of innovation studies in both developed (e.g. Griffith et al., 2004; Griffith et al., 2006; Mohnen et al., 2006) and developing countries (e.g. Chudnovsky et al., 2006; Hegde and Shapira, 2007; Jefferson et al., 2006) as well as in previous IVC studies (e.g. Doran and O'Leary, 2011; Ganotakis and Love, 2012; Roper et al., 2008; Roper and Arvanitis, 2012). Different affects are found for the relationship between external R&D and innovation. The UKIS dataset shows positive and significant relationships between external R&D and product innovation, including new to the market and new to firm innovations, and between external R&D and innovation success (see Table 4.9). The IIS 2011 dataset shows positive significant impacts between: external R&D and product innovation new to the markets, external R&D and process innovation, and external R&D and organisational innovation (see Table 4.8). Therefore, it can be summarised that internal R&D in both Indonesian and UK firms has a consistent, positive and strong impact on innovation and innovation success. However external R&D has different directions of impact on innovation and innovation success.

Based on these findings, Hypothesis 2a is partially supported. Internal R&D has consistently strong effects for both countries, notwithstanding the lower levels of R&D inputs available to Indonesian firms. However, external R&D is clearly harnessed to a much greater extent and more consistently by UK firms.

4.4.3.2. Informal knowledge

Table 4.8 reports that overall external knowledge from *market/commercials* networks such as customers and competitors and *open sources* such as events positively and significantly affects innovation and innovation success in Indonesia. Each source of knowledge affects at least four different types of innovation and innovation success. In UK firms, only customers widely, positively and significantly impact different types of innovation (see Table 4.9). This may indicate that informal knowledge agents for Indonesian firms play more important roles in shaping innovation than in UK firms. Therefore, Hypothesis 2b is supported.

4.4.3.3. External knowledge breadth

Tables 4.8 and 4.9 clearly show that overall external knowledge breadth (BREADTH) has positive and significant impact on all types of innovation and innovation success, while BREADTH squared has a negative influence on innovation and innovation success for both countries. This indicates that when the firms use too much external knowledge in the knowledge transformation activity, experience diminishing returns in the form of decreases in innovation and innovation success. This evidence supports previous open innovation studies (e.g. Laursen and Salter, 2006, 2007). Therefore, Hypothesis 2c is supported.

4.4.3.4. Formal cooperation

In terms of formal cooperation, the IIS 2011 data set shows that only formal cooperation activity with suppliers contributes positively and significantly correlates with innovation and innovation success (see Table 4.8). In contrast, in UK firms, it can be observed that more formal cooperation activities have positive and significant impacts on innovation and innovation success. In general, cooperation with firm groups, suppliers and competitors has positive impacts on innovation. Suppliers and competitors also positively and significantly affect innovation success (see Table 4.9). However, formal cooperation with science institutions yields very few positive impacts on innovation or innovation success in either country. This indicates a more positive and significant impact of formal cooperation on innovation in UK firms than in Indonesian firms. In summary, formal cooperation activities beyond supply chain linkages also positively affect innovation, especially for UK firms. However, such cooperation activities are more likely to be involve market/commercials networks.

4.4.3.5. Innovation barriers

Indonesian firms tend to face innovation barriers related to risk, external funding and market domination, and these types of barriers have a positive impact on various types of innovation (see Table 4.8). The positive association means that, despite innovative firms experiencing these barriers during in the innovation process, they do not prevent innovation from occurring and hence, they are known as revealing barriers (D'Este et al., 2012). Negative impacts of constraints related to risk and market information on organisational innovation were also found. After firms innovate, risk barriers positively impact the innovation success of Indonesian firms.

UK firms are more likely face market domination constraint and this has a negative impact on various types of innovation (see Table 4.9). The negative link indicates that the constraint tends to demotivate UK firms to innovate and these factors are called deterring barriers (D'Este et al., 2012). In addition, lack of information on technology was found to negatively affect both product innovation and new to the firm innovation. In contrast, lack of qualified personnel was found to positively impact the same innovation. In total, Indonesia firms have 24 combinations that consist of 16 positive and 8 negative associations between

innovation barriers and innovation, while the UK firms show 20 combinations, 6 of which are positive and 14 are negative. Based on this, and on the fact that in Indonesia, positive associations between barriers and innovation are more common than negative associations, it is invalid to conclude that Indonesian firms face greater innovation barriers than UK firms and therefore, Hypothesis 2d is not supported. Notice that the results suggest that, while Indonesian firms indicate that they face more innovation barriers than UK firms (see Table 3), this does not appear to translate into markedly greater innovation. It should also be noted that the pattern of barrier effects on innovation is rather different in the two countries, perhaps reflecting the different internal resources of firms in the two contrasting countries.

In Indonesia, firm resources appear to have no significant influence on innovation. Employment is more likely to have a negative effect on innovation and innovations success, but exporters and quality of employees are positively associated with innovation and innovation success. High technology is positively associated with all types of product innovation and with innovation success. In the case of UK firms, exporters are more likely have positive relationships with innovation and innovation success. In contrast, technology intensity negatively influences innovation and innovation success. Employment and employee quality variables have mixed impacts on innovation.

Table 4.8 Knowledge trasformation activities: The IIS 2011

INDEPENDENT VARIABLES	PRODUCT INNOVATION		PRODINOV_NEW2MARKET		PRODINOV_NEW2FIRMS	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
INTERNAL_RD	**.265*** (.021)**	**.136*** (.022)**	**.185*** (.023)**	**.073*** (.023)**	**.249*** (.022)**	**.126*** (.022)**
EXTERNAL_RD	.076 (.081)	.040 (.067)	**.116*** (.070)	.082 (.059)	.127 (.081)	.084 (.069)
Market agents						
SUPPLIERS	**-.050* (.030)**		-.044 (.029)		-.044 (.0290	
CUSTOMERS	**.168*** (.027)**		**.135*** (.027)**		**.150*** (.027)**	
COMPETITORS	.042 (.030)		**.104*** (.028)**		**.051* (.030)**	
CONSULTANTS	**.097* (.052)**		.069 (.047)		**.112** (.051)**	
Science institutions						
UNIVERSITIES	.072 (.068)		.053 (.061)		.045 (.066)	
GOV_RD	-.105 (.069)		.025 (.064)		-.061 (.068)	
Associations						
IND_ASSOC.	-.063 (.050)		**-.104** (.047)**		**-.099** (.049)**	
Open sources						
EVENTS	**.220*** (.045)**		**.202*** (.039)**		**.203*** (.043)**	
SCIENCE_PUB	-.041 (.053)		-.028 (.047)		-.011 (.052)	
External knowledge breadth						
BREADTH		**.193*** (.017)**		**.173*** (.020)**		**.194*** (.018)**
$BREADTH^2$		**-.014*** (.002)**		**-.012*** (.002)**		**-.014*** (.002)**
Formal cooperation						
COOP_FIRMGROUP	.016 (.091)	.018 (.076)	.101 (.081)	.092 (.070)	-.033 (.085)	-.020 (.071)
COOP_SUPPLIERS	**.168** (.068)**	**.111* (.059)**	**.115* (.062)**	.089 (.055)	**.134** (.065)**	.093 (.058)
COOP_COMPETITORS	-.116 (.124)	-.068 (.099)	-.146 (.108)	-.129 (.093)	-.026 (.123)	-.015 (.100)
COOP_CONSULTANT	-.161 (.105)	**-.147* (.086)**	-.148 (.102)	**-.157* (.086)**	**-.194* (.105)**	**-.165* (.085)**
COOP_UNIVERSITIES	.179 (.147)	.072 (.112)	.068 (.125)	.009 (.095)	.232 (.148)	.109 (.117)
COOP_GOVRD	.017 (.174)	-.011 (.134)	-.031 (.154)	.017 (.118)	-.021 (.177)	-.018 (.139)
Financial barriers						
INBAR_HIGHRISK	**.057* (.033)**	.043 (.028)	**.065** (.033)**	.040 (.028)	.049 (.033)	.036 (.028)
INBAR_HIGHCOST	.022 (.033)	-.007 (.028)	.016 (.033)	-.003 (.028)	.016 (.033)	-.007 (.028)

INBAR_INFUND	.045 (.038)	.041 (.032)	.037 (.038)	.030 (.031)	**.063*(.038)**	**.054*(.032)**
INBAR_EXFUND	-.025 (.037)	-.036 (.031)	**-.085**(.036)**	**-.080***(.030)**	-.013 (.036)	-.027 (.031)
Knowledge barriers						
INBAR_PERSON	.050 (.034)	.013 (.029)	-.043 (.034)	**-.064**(.030)**	.053 (.033)	.015 (.029)
INBAR_TECHINFO	.039 (.036)	.010 (.030)	.017 (.036)	.007 (.031)	.045 (.036)	.020 (.030)
INBAR_MKTINFO	-.019 (.037)	.003 (.032)	.002 (.037)	.015 (.032)	-.004 (.037)	.011 (.032)
Market barriers						
INBAR_MKTDOM	.028 (.032)	-.007 (.027)	-.023 (.032)	-.040 (.027)	.032 (.032)	-.003 (.027)
INBAR_UNDEMAND	-.028 (.034)	-.001 (.028)	-.027 (.034)	.003 (.029)	-.031 (.034)	-.005 (.029)
Institution barriers						
INBAR_GOVRD	-.035 (.036)	.015 (.030)	-.011 (.035)	.034 (.030)	-.073 (.036)	-.016 (.030)
Firm resources						
EMPLOYMENT	-.00001(.00002)	-.00002(.00003)	-.00001(.00002)	-.00003(.00003)	-.000003(.00001)	-.00001 (.00003)
EXPORTERS	.027(.028)	.004 (.026)	.045 (.028)	.023 (.026)	.043 (.028)	.021 (.026)
UNDERGRAD	.001(.001)	.0004 (.001)	.002 (.001)	.001 (.001)	.001 (.001)	.001 (.001)
LOW_TECH	-	-	-	-	-	-
MEDLOW_TECH	.028 (.031)	.041 (.029)	.021 (.031)	.022 (.030)	.036 (.031)	.046 (.030)
MEDHIGH_TECH	.037 (.040)	.030 (.038)	.066 (.042)	.035 (.039)	.042 (.041)	.030 (.039)
HIGH_TECH	.056 (.129)	.102 (.107)	.124 (.135)	.173 (.111)	.084 (.129)	.122 (.107)
Observation	1179	1179	1179	1179	1179	1179
LR chi2 ()	484	623.95	334.26	467.36	457.3	594.32
Prob. > chi2	.000	.000	.000	.00	.000	.000
Pseudo R2	.310	.400	.240	.330	.297	.386
Log likelihood	-538.93	-468.96	-540.18	-473.64	-540.32	-471.80
Mean VIF	1.63		1.63		1.63	

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the models are marginal effects generated from logit models.

Table 4.8 Knowledge trasformation activities: The IIS 2011 *(Continued)*

INDEPENDENT VARIABLES	PROCESS INNOV.		ORG. INNOV.		MARKETING INNOV.		INNSUCCESS	
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
INTERNAL_RD	.**293*****(.017)	.**192*****(.018)	.**360*****(.015)	.**254*****(.016)	.**284*****(.021)	.**166*****(.022)	**22.66*****(3.40)	**8.99*****(3.22)
EXTERNAL_RD	.**172****(.084)	.120 (.076)	.**143***(.086)	.**129***(.075)	-.109 (.082)	-.097 (.069)	6.92 (7.99)	6.90 (7.29)
Market agents								
SUPPLIERS	-.015 (.028)		-.030 (.028)		-.004 (.029)		-5.70 (3.79)	
CUSTOMERS	.**053****(.027)		.**056****(.028)		.**181*****(.026)		**19.18*****(3.69)	
COMPETITORS	.**085*****(.027)		.042 (.029)		.**095*****(.030)		**10.22*****(3.71)	
CONSULTANTS	.042 (.046)		.026 (.047)		.058 (.052)		8.34 (5.71)	
Scientific institutions								
UNIVERSITIES	-.**176*****(.059)		.009 (.059)		.037 (.064)		6.38 (7.03)	
GOV_RD	.**158****(.065)		-.089 (.061)		-.089 (.067)		3.99 (7.54)	
Associations								
IND_ASSOC.	-.027 (.044)		.044 (.047)		-.033 (.049)		-8.65 (5.88)	
Open sources								
EVENTS	.049 (.037)		.063 (.040)		.027 (.043)		**18.84*****(4.73)	
SCIENCE_PUB	-.030 (.045)		-.**093***(.048)		-.007 (.051)		-3.84 (5.77)	
External knowledge breadth								
BREADTH	-	.**150*****(.019)	-	.**179*****(.015)	-	.**179*****(.016)	-	**24.21*****(2.85)
BREADTH^{2}	-	-.**011*****(.002)	-	-.**016*****(.001)	-	-.**014*****(.002)	-	-**1.63*****(.26)
Formal cooperation								
COOP_FIRMGROUP	.057 (.093)	.041 (.083)	-.023 (.083)	-.016 (.077)	-.034 (.093)	-.036 (.080)	.07 (9.19)	2.87 (8.35)
COOP_SUPPLIERS	.065 (.065)	.044 (.059)	.026 (.067)	-.028 (.061)	.**277*****(.075)	.**191*****(.067)	**17.82****(7.65)	**14.78****(7.04)
COOP_COMPETITORS	.242 (.184)	.163 (.157)	-	-	-.**284****(.140)	-.153 (.121)	-13.93 (14.14)	-14.22 (12.84)
COOP_CONSULTANT	.165 (.107)	.132 (.098)	.**255****(.112)	.**204****(.104)	.033 (.108)	.031 (.095)	-17.38 (11.88)	-**23.09****(10.89)
COOP_UNIVERSITIES	.**257****(.128)	.081 (.115)	.221 (.145)	.144 (.135)	.152 (.145)	.009 (.116)	5.98 (13.75)	-.40 (12.34)
COOP_GOVRD	-.178 (.186)	-.051 (.161)	-.**342***(.179)	-.**267***(.162)	-	-	-3.49 (17.37)	4.68 (15.72)
Financial barriers								

INBAR_HIGHRISK	.038 (.030)	.020 (.027)	-.**083*****(.032)	-.**072*****(.027)	.048 (.033)	.**050***(.028)	**9.80****(4.19)	**7.27***(3.80)
INBAR_HIGHCOST	.**059***(.030)	.033 (.027)	-.011 (.032)	-.035 (.028)	.032 (.033)	.003 (.029)	1.99 (4.31)	-0.96 (3.89)
INBAR_INFUND	.034 (.035)	.022 (.031)	-.038 (.036)	-.039 (.030)	.008 (.037)	.022 (.032)	.73 (4.74)	1.04 (4.25)
INBAR_EXFUND	-.021 (.034)	-.022 (.030)	.**118*****(.035)	.**081*****(.030)	.**089****(.035)	.**061****(.031)	-4.30 (4.53)	-5.85 (4.15)
Knowledge barriers								
INBAR_PERSON	.016 (.032)	-.003 (.028)	-.026 (.033)	-.034 (.028)	.052 (.034)	.022 (.030)	-5.33 (4.42)	-**9.48****(4.05)
INBAR_TECHINFO	.018 (.033)	.010 (.029)	.009 (.035)	-.005 (.030)	-.035 (.036)	-.**054***(.030)	.69 (4.57)	-0.69 (4.20)
INBAR_MKTINFO	-.035 (.034)	-.027 (.031)	-.**064***(.036)	-.024 (.031)	-.019 (.037)	.013 (.033)	-.21 (4.70)	1.66 (4.30)
Market barriers								
INBAR_MKTDOM	.**064****(.029)	.033 (.026)	.**053***(.031)	.025 (.027)	.**060***(.031)	.026 (.027)	-1.90 (4.09)	-5.08 (3.72)
INBAR_UNDEMAND	-.009 (.031)	.014 (.028)	.031 (.034)	.031 (.028)	-.019 (.034)	.001 (.029)	1.30 (4.29)	4.01 (3.90)
Institution barriers								
INBAR_GOVD	.038 (.033)	.**053***(.029)	.002 (.034)	.004 (.029)	.016 (.036)	.040 (.031)	-.60 (4.48)	4.25 (4.05)
Firm resources								
EMPLOYMENT	-.0000001 (.00001)	.000003 (.00002)	-.00001 (.00002)	-.00001 (.00003)	-.00001 (.00002)	-.00002 (.00003)	-.001 (.002)	-.001 (.004)
EXPORTERS	-.009 (.028)	-.022 (.026)	-.016 (.027)	-.022 (.026)	.025 (.027)	.015 (.026)	4.95 (3.63)	1.49 (3.58)
UNDERGRAD	-.0002 (.001)	.00004 (.001)	.0001 (.001)	.0001 (.001)	.001 (.001)	.001 (.001)	.27 (.16)	.**29***(.16)
LOW_TECH	-	-	-	-	-	-	-	-
MEDLOW_TECH	-.027 (.030)	-.025 (.029)	-.004 (.030)	.002 (.029)	-.028 (.030)	-.014 (.029)	2.51 (4.01)	2.74 (4.03)
MEDHIGH_TECH	.006 (.039)	-.007 (.037)	-.044 (.037)	-.049 (.036)	.038 (.040)	.046 (.037)	6.14 (5.25)	2.67 (5.18)
HIGH_TECH	-.198 (.085)	-.126 (.103)	.048 (.118)	.075 (.101)	.045 (.118)	.050 (.110)	7.91 (14.41)	16.91 (13.76)
Observation	1179	1179	1165	1165	1170	1170	1179	1179
LR chi2 ( )	486.1	577.49	434.09	549.76	575.47	669.83	282.34	452.45
Prob > chi2	.000	.000	.000	.000	.000	.000	.000	.000
Pseudo R2	.328	.390	.304	.385	.361	.420	.065	.104
Log likelihood	-498.07	-452.37	-496.72	-438.88	-509.66	-462.47	-2027.13	-1942.08
Mean VIF	1.63		1.63		1.63		1.53	

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the models are marginal effects generated from logit models.

Table 4.9 Knowledge trasformation activities: The UKIS 2011

INDEPENDENT VARIABLES	PRODUCT INNOVATION		PRODINOV_NEW2MARKET		PRODINOV_NEW2FIRMS	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
INTERNAL_RD	**.222***(.020)**	**.167***(.019)**	**.221***(.025)**	**.183***(.024)**	**.180***(.026)**	**.128**(.024)**
EXTERNAL_RD	**.078**(.031)**	**.071***(.028)**	**.070***(.025)**	**.067***(.024)**	**.086***(.030)**	**.078***(.027)**
Market agents						
SUPPLIERS	.021 (.029)		.004 (.026)		.036 (.029)	
CUSTOMERS	**.168***(.023)**		**.104***(.023)**		**.141***(.025)**	
COMPETITORS	.031 (.038)		-.033 (.030)		.043 (.036)	
CONSULTANTS	.025 (.056)		.067 (.046)		-.023 (.053)	
Scientific institutions						
UNIVERSITIES	.038 (.104)		.038 (.076)		-.033 (.088)	
GOV_RD	-.088 (.089)		.082 (.074)		-.010 (.085)	
Associations						
IND_ASSOC.	**-.179***(.060)**		**-.106**(.052)**		**-.116*(.059)**	
Open sources						
EVENTS	.040 (.056)		**.120*** (.046)**		.028 (.054)	
SCIENCE_PUB	-.125 (.076)		-.104 (.065)		-.016 (.077)	
External knowledge breadth						
BREADTH		**.116***(.042)**		**.179***(.056)**		**.127**(.055)**
BREADTH^2		-.007 (.004)		**-.014**(.006)**		-.007 (.006)
Formal cooperation						
COOP_FIRMGROUP	**.071**(.029)**	.018 (.024)	.026 (.025)	.010 (.024)	**.053*(.029)**	.017 (.026)
COOP_SUPPLIERS	**.088***(.027)**	**.039*(.023)**	**.066***(.025)**	**.040*(.023)**	**.097***(.028)**	**.054**(.025)**
COOP_COMPET.	**.116***(.044)**	**.096***(.036)**	**.108***(.032)**	**.093***(.030)**	**.084**(.039)**	**.078**(.034)**
COOP_CONSUL.	.037 (.038)	-.003 (.030)	-.009 (.030)	-.008 (.027)	-.058 (.036)	**-.067**(.031)**
COOP_UNIV.	.015 (.042)	.008 (.034)	.022 (.033)	.020 (.029)	.036 (.039)	.024 (.034)
COOP_GOVRD	.009 (.055)	.001 (.042)	.032 (.040)	.035 (.037)	.046 (.049)	.043 (.042)
Financial barriers						
INBAR_ECONRISK	.013 (.033)	-.010 (.030)	**-.062*(.034)**	**-.068**(.032)**	-.003 (.036)	-.018 (.033)

INBAR_HIGHCOST	**.065*(.033)**	**.052*(.030)**	.032 (.032)	.017 (.030)	.049 (.035)	.043 (.032)
INBAR_COSTFIN	-.019 (.041)	-.021 (.037)	-.009 (.041)	-.005 (.039)	-.022 (.044)	-.015 (.041)
INBAR_FINABLE	.009 (.040)	.030 (.036)	-.001 (.038)	.005 (.036)	.041 (.041)	.048 (.039)
Knowledge barriers						
INBAR_PERSON	**.082*(.050)**	**.083*(.046)**	.012 (.045)	.010 (.043)	**.147***(.050)**	**.147***(.049)**
INBAR_TECHINFO	**-.177**(.071)**	**-.149**(.059)**	-.023 (.070)	-.012 (.066)	**-.182**(.079)**	**-.185***(.071)**
INBAR_MKTINFO	.023 (.072)	-.007 (.063)	-.044 (.066)	-.043 (.061)	.066 (.073)	.051 (.067)
Market barriers						
INBAR_MKTDOM	**-.081*(.043)**	-.032 (.040)	**-.099**(.045)**	**-.074*(.043)**	-.025 (.045)	.022 (.045)
INBAR_UNDEMAND	-.067 (.041)	-.025 (.038)	-.037 (.041)	-.017 (.039)	.011 (.043)	.050 (.042)
Institution barriers						
INBAR_GOVRD	.073 (.052)	.028 (.044)	.073 (.044)	.060 (.041)	-.009 (.050)	-.023 (.045)
Firm resources						
EMPLOYMENT	-.00003 (.00003)	-.00002 (.00002)	.00002 (.00003)	.00002 (.00002)	**-.0001*(.00003)**	-.00004 (.00003)
EXPORTERS	.030 (.024)	.031 (.022)	.041 (.025)	**.042*(.024)**	.036 (.027)	.035 (.025)
EDU_SCIENCE	.001 (.001)	-.0001 (.001)	.001 (.001)	.001 (.001)	-.002 (.001)	-.002 (.001)
EDU_OTHER	.0003 (.001)	**.002**(.001)**	-.0005 (.001)	.0005 (.001)	**.002*(.001)**	**.004***(.001)**
LOW_TECH	-	-	-	-	-	-
MEDLOW_TECH	-.025 (.027)	-.006 (.025)	-.018 (.028)	-.015 (.027)	-.046 (.030)	-.030 (.028)
MEDHIGH_TECH	.010 (.029)	.022 (.026)	-.003 (.028)	.001 (.027)	-.020 (.031)	-.009 (.029)
HIGH_TECH	.049 (.047)	.048 (.041)	.003 (.043)	-.0001 (.040)	-.033 (.048)	-.029 (.044)
Observation	1371	1428	1371	1428	1371	1428
LR chi2(42)	587.30	816.62	405.62	477.42	360.22	532.29
Prob > chi2	.000	.000	.000	.000	.000	.000
Pseudo R2	.310	.413	.244	.280	.196	.281
Log likelihood	-653.36	-581.00	-630.15	-613.78	-740.36	-682.31
Mean VIF	1.59		1.59		1.59	

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the models are marginal effects generated from logit models.

Table 4.9 Knowledge trasformation activities: The UKIS 2011 *(Continued)*

INDEPENDENT VARIABLES	PROCESS INNOV.		ORG. INNOV.		MARKETING INNOV.			INNSUCCESS
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
INTERNAL_RD	.**125*****(.027)	.**070*****(.025)	.**108*****(.029)	.**105*****(.029)	.**162*****(.027)	.**149*****(.026)	**11.94*****(1.803)	**10.74*****(1.82)
EXTERNAL_RD	.017 (.030)	.013 (.027)	.046 (.036)	.047 (.035)	.031 (.028)	.033 (.027)	**4.17****(1.671)	**3.99****(1.67)
Market agents								
SUPPLIERS	.**114*****(.028)		.**115*****(.034)		.**056****(.027)		2.36 (1.652)	
CUSTOMERS	.**053****(.026)		.066 (.030)		.007 (.026)		**6.14*****(1.563)	
COMPETITORS	-.014 (.035)		-.025 (.042)		.039 (.033)		-2.32 (1.994)	
CONSULTANTS	-.048 (.052)		.067 (.068)		.011 (.048)		2.39 (2.744)	
Science institutions								
UNIVERSITIES	.122 (.085)		.026 (.108)		-.041 (.076)		3.61 (4.391)	
GOV_RD	.022 (.084)		-.022 (.105)		.041 (.077)		3.86 (4.280)	
Associations								
IND_ASSOC.	-.041 (.059)		.061 (.077)		.083 (.053)		-**6.80****(3.353)	
Open sources								
EVENTS	.**123****(.053)		.022 (.067)		.011 (.050)		**7.24****(2.836)	
SCIENCE_PUB	-.006 (.076)		-.001 (.102)		.090 (.070)		1.54 (4.108)	
External knowledge breadth								
BREADTH		.**335*****(.053)		.**136****(.054)		.009 (.051)		4.89 (4.02)
BREADTH^{2}		-.**030*****(.005)		-.**013****(.006)		.0005 (.006)		-.18 (.42)
Formal cooperation								
COOP_FIRMGROUP	.**165*****(.027)	.**123*****(.025)	.**093*****(.034)	.**082****(.034)	.016 (.028)	.013 (.027)	-.12 (1.678)	-1.24 (1.66)
COOP_SUPPLIER	.**100*****(.028)	.**076*****(.025)	.**099*****(.033)	.**110*****(.031)	.**094*****(.027)	.**088*****(.026)	**6.93*****(1.682)	**5.87*****(1.64)
COOP_COMPET	-.048 (.038)	-.040 (.034)	.008 (.047)	.008 (.045)	.**065***(.035)	.**076****(.033)	**4.94****(2.052)	**5.09****(2.03)
COOP_CONSUL	-.007 (.035)	-.014 (.031)	.**083***(.043)	.**089****(.041)	.**067****(.032)	.071 (.030)	-.83 (1.956)	-.91 (1.89)
COOP_UNIV.	.**064****(.038)	.**063***(.033)	-.092**(.046)	-.**092****(.043)	.020 (.036)	.006 (.033)	-2.72 (2.114)	-2.49 (2.02)
COOP_GOVRD	-.004 (.047)	-.0002 (.041)	-.017 (.059)	-.008 (.055)	-.051 (.044)	-.035 (.041)	1.67 (2.502)	1.77 (2.41)
Financial barriers								

INBAR_ECONRISK	-.024 (.036)	-.019 (.033)	.027 (.039)	.028 (.038)	-.039 (.035)	-.030 (.033)	**-4.92****(2.239)	**-5.04****(2.25)
INBAR_HIGHCOST	.004 (.035)	-.003 (.033)	.022 (.038)	.024 (.037)	.012 (.033)	.017 (.032)	2.52 (2.062)	1.76 (2.08)
INBAR_COSTFIN	-.007 (.044)	.018 (.041)	.009 (.048)	.017 (.047)	.041 (.041)	.050 (.040)	-2.90 (2.676)	-2.58 (2.71)
INBAR_FINABLE	-.019 (.042)	-.035 (.039)	.042 (.046)	.046 (.045)	.032 (.039)	.029 (.038)	3.50 (2.474)	4.28 (2.53)
Knowledge barriers								
INBAR_PERSON	.030 (.051)	.004 (.046)	.063 (.056)	.037 (.054)	.023 (.046)	.004 (.044)	2.78 (3.002)	2.03 (3.01)
INBAR_TECHINFO	.027 (.074)	.024 (.067)	.026 (.086)	.042 (.083)	-.051 (.070)	-.046 (.067)	.75 (4.427)	.97 (4.44)
INBAR_MKTINFO	.070 (.070)	.070 (.064)	.138 (.087)	.130 (.083)	**.103***(.062)	**.109***(.060)	-4.52 (4.098)	-3.84 (4.10)
Market barriers								
INBAR_MKTDOM	-**.094****(.047)	-.063 (.045)	-.011 (.047)	.008 (.047)	-.016 (.044)	-.001 (.042)	-2.77 (2.871)	-1.20 (2.99)
INBAR_UNDEMAND	-.093 (.045)	-.063 (.042)	-**.098****(.046)	-**.089****(.045)	.021 (.041)	.024 (.040)	-1.35 (2.594)	-.18 (2.66)
Institution barriers								
INBAR_GOVREG	-.009 (.051)	-.018 (.045)	-.081 (.056)	-**.092***(.052)	-.007 (.046)	.002 (.043)	2.52 (2.817)	2.24 (2.78)
Firm Resources								
EMPLOYMENT	.00004(.00003)	.00004(.00003)	.00004(.00003)	.00005(.00003)	-**.0001*****(.00004)	-**.0001*****(.00004)	.002 (.002)	.002 (.002)
EXPORT	.005 (.027)	.017 (.026)	-.021 (.028)	-.012 (.027)	-.003 (.026)	.0004 (.025)	**4.41*****(1.696)	**4.59*****(1.73)
EDU_SCIENCE	-.0004 (.001)	-.0004 (.001)	.001 (.002)	.001 (.001)	-.001 (.001)	-.001 (.001)	**.19*****(.070)	**.19*****(.07)
EDU_OTHERS	-.001 (.001)	-.0004 (.001)	**.003****(.001)	**.004****(.001)	.0003 (.001)	.001 (.001)	.004 (.068)	.075 (.07)
LOW_TECH	-	-	-	-	-	-	-	-
MEDLOW_TECH	-**.077****(.030)	-**.078*****(.029)	.0001 (.032)	.007 (.030)	.008 (.030)	.005 (.029)	-2.292 (1.888)	-2.258 (1.932)
MEDHIGH_TECH	-**.084*****(.031)	-**.088*****(.029)	-.010 (.034)	-.012 (.032)	-.047 (.030)	-.045 (.029)	1.045 (1.825)	1.202 (1.849)
HIGH_TECH	-.037 (.048)	-.051 (.044)	-.014 (.053)	-.023 (.051)	-**.076***(.043)	-**.079***(.041)	-.402 (2.790)	-.709 (2.783)
Observation	1371	1428	1371	1428	1371	1428	1233	1283
LR chi2 ( )	301.83	440.55	222.85	267.64	220.01	233.47	341.16	400.55
Prob. > chi2	.000	.000	.000	.000	.000	.000	.000	.000
Pseudo R2	.170	.242	.118	.136	.137	.142	.087	.101
Log likelihood	-736.21	-690.73	-829.64	-852.35	-692.44	-703.38	-1800.79	-1786.78
Mean VIF	1.59		1.59		1.59		1.40	

Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. All figures in the models 7-12 are marginal effects generated from Logit models and models 13 and 14 (innovation success) derived from Tobit regression.

4.4.4. Knowledge exploitation activity

The final link in the IVC is knowledge exploitation activity and Table 4.10 shows the link for both Indonesia and the UK. The focus here is on the impact of innovative indicators on firms' productivity. For both countries, innovation success has negative effects on productivity. According to Roper et al. (2008) this phenomenon can be ascribed to a disruption effect. For both countries, new to the market innovation has a positive correlation with firms' productivity. In contrast, new to the firm innovation has the opposite effect on productivity. However, these impacts are not significant.

Four types of innovative indicators affect firms' productivity in both countries. For the UK, only process innovation positively and significantly impacts productivity, whereas other innovation indicators, including product, organisational and marketing, have negative associations with firms' productivity. For Indonesia, evidence shows that only marketing innovation negatively and significantly affects productivity, but both process and organisational innovation positively and significantly influence productivity. While product innovation has a positive association with productivity, it does not have a significant impact. This suggests that both technological (i.e. process innovation) and non-technological (i.e. organisational innovation) innovations play important roles in Indonesia firms' productivity. However, only technological innovation (i.e. process innovation) was found to be important for UK firms' productivity. Based on this finding, Hypothesis H3 can be supported.

Firm resources influence productivity in different directions for each country. For Indonesia, employment and exporters have negative associations with productivity, while the other resources such as employee quality and technology intensity have positive effects on productivity. For UK firms, employment, exporters, and employees that hold science degrees positively and significantly impact productivity. The other firm resources are also positively association with productivity. For both countries, status as a medium to high technology firm contributes positively and significantly to productivity.

Table 4.10 Knowledge exploitation activity: THE IIS 2011 and The UKIS 2011

INDEPENDENT VARIABLES	INDONESIA		THE UK	
	Model 1 PRODUCTIVITY	Model 2 PRODUCTIVITY	Model 3 PRODUCTIVITY	Model 4 PRODUCTIVITY
PRODINOV	-	212.24 (1120.33)	-	-1.93 (10.02)
PRODINOV_NEW2MARKET	675.74 (1120.33)	-	15.10 (12.10)	-
PRODINN_NEW2FIRM	-103.73 (816.24)	-	**-17.93*(9.64)**	-
PROCINOV	**1985.38***(628.94)**	**2005.00***(626.94)**	**31.55***(9.96)**	**30.39***(10.04)**
ORGINOV	**2485.78***(629.52)**	**2495.26***(630.03)**	-9.22 (9.53)	-9.09 (9.56)
MKTGINOV	**-1708.53***(602.74)**	**-1699.13***(601.40)**	-.94 (10.54)	-1.96 (10.51)
INNSUCCESS	-28.43(23.05)	-20.06 (18.57)	**-1.09*(.62)**	-.71 (.55)
Firm Resources				
EMPLOYMENT	-.09(.18)	-.09 (.18)	**.06***(.01)**	**.06***(.01)**
EXPORTERS	-795.80(614.85)	-782.51(614.12)	**36.13***(9.47)**	**35.72***(9.47)**
UNDERGRAD	**51.74*(28.10)**	51.71 (28.10)	-	-
EDU_SCIENCE	-	-	**2.02***(.48)**	**2.01***(.48)**
EDU_OTHER	-	-	.41 (.46)	.36 (.46)
LOW_TECH	-	-	-	-
MEDLOW_TECH	700.94 (644.33)	696.29(643.90)	-14.95 (10.76)	-14.11 (10.77)
MEDHIGH_TECH	**2062.80**(887.39)**	2079.44(886.71)	**18.66*(11.34)**	18.53 (11.37)
HIGH_TECH	2671.89(2517.17)	2722.79(2515.05)	8.67 (17.67)	9.24 (17.72)
Observation	1179	1179	1281	1281
F ( )	4.42	4.79	10.22	10.70
Prob. > F	.000	.000	.000	.000
R^2	.044	.043	.095	.092
Adj. R^2	.034	.034	.086	.083

*Notes: Significant levels *p≤.10, **p≤.05, ***p≤.001. The results are based on OLS regressions.*

4.5. Discussion and Conclusions

This study compares the IVC that is composed of three main links: knowledge sourcing, transformation and exploitation activities performed by manufacturing firms in a developing country, Indonesia, and a developed country, the UK, using innovation data derived from the IIS 2011 and the UKIS 2011. It provides the first empirical evidence of differences in IVCs between developing and developed economies as previous comparisons in IVC studies focus only on advanced countries. The evidence presented in this study suggests that, in each IVC link, similarities and differences on the causal links from knowledge sourcing through innovation to firm performance between Indonesian and UK firms can be identified. Three group sources of knowledge; firm characteristics and resources; and innovation barriers shape the IVC differences between the two countries.

As predicted, the proportion of UK firms that source knowledge from both internal and external R&D as well as from formal cooperation, is greater than their manufacturing counterparts in Indonesia. Indonesian firms tend to use a higher proportion of informal knowledge that is sourced from market/commercials networks, science institutions, associations and open sources. In terms of firm resources, UK firms have more employees, a higher proportion of exporters and higher proportion of non-low technology firms than Indonesian firms. On average, Indonesian firms face greater innovation barriers than UK firms. Interestingly, Indonesian firms produce a greater range of innovation, except for organisational innovation, than UK firms.

In the first link of the IVC, this study finds strong evidence for synergistic relationships between firms' knowledge sourcing activities in the two countries. For example, synergistic relationships are found between internal and external R&D and between internal R&D and market/commercials networks. A clear distinction between the two countries in this link is the existence of synergistic relationships between both internal and external R &D activities and formal cooperation and between external R&D and other external sources for UK firms, while for Indonesia this relationship does not exist.

In terms of firm resources, UK firms show positive associations with a range of sources of knowledge. In contrast, the Indonesian firms show negative associations. The synergistic relationship between internal and external knowledge in Indonesian firms may indicate the implementation of open innovation strategy. Further differences can also be found in UK exporters and high technology firms. UK exporters tend to source knowledge from internal R&D and diverse external knowledge providers as well as participating in more formal cooperation. High technology UK firms are more likely to source knowledge from internal R&D and science institutions.

Evidence shows that Indonesian firms experience greater constraints than the UK firms. In addition, Indonesian firms have weaknesses related to the industrial system that consist of "knowledge-based industrial transformation; balanced technology absorption from R&D and learning; and shifting the policy orientation from economic to techno-economic development" (Gammeltoft and Aminullah, 2006b, p.149).

This may pressure Indonesian firms to engage with external partners to overcome innovation barriers and to compensate for a shortage of resources and technological capability. However, evidence shows that synergistic relationships exist between internal R&D and market/commercials networks and this may suggest the need for a more differentiated approach to knowledge sourced from diverse sources and firms' abilities to absorb knowledge from different sources. Previous studies suggest that sourcing knowledge from diverse sources can increase the degree of innovation novelty (Amara and Landry, 2005) and also make replication more difficult, leading to sustainable competitive advantage (Henderson and Cockburn, 1994).

In the second link of the IVC, how different ranges of knowledge impact innovation is compared. Of the three groups of sources of knowledge, R&D activity is the most consistently positively correlated with innovation and innovation success in both countries. For UK firms, both internal and external R&D appears to have a direct impact on innovation. For Indonesia, the positive and significant impact of internal R&D on innovation is stronger than that for external R&D. Evidence for this link also reveals that informal knowledge sourced from market/commercial links makes a greater contribution to innovation and innovation success for Indonesian firms than for UK firms. On the contrary, formal cooperation makes greater contributions to innovation for the UK than for Indonesia. However, such cooperation is more likely to be conducted with market/commercial networks. The similarity of evidence in both countries in terms of the positive role of R&D activities and of market/commercial networks in shaping innovation suggests that the firms should explore external networks beyond these sources of knowledge to improve their innovativeness. This finding confirms Laursen and Salter's (2004) work that argues that a larger proportion of UK firms use more "conventional" knowledge sources such as internal R&D, suppliers and customers as the main source of knowledge in innovation activities. Science institutions such as universities may provide more reliable knowledge, but it may takes time to produce advanced technology that is ready to be implemented.

In terms of the associations between barriers and innovation, Indonesian firms have more positive associations than UK firms. This phenomenon should be interpreted carefully as this does not guarantee that Indonesian firms have better abilities to overcome barriers since the nature of barriers and firm resources differs between the two countries. A possible reason is that, the higher proportion of innovators in Indonesia, except organisational innovators, than in the UK, may provide a greater the awareness of the importance of obstacles to innovation and, hence, the obstacles do not prevent Indonesian firms from innovating. This is an example of the phenomenon of revealing barriers and supports the results of previous innovation barrier studies that employ CIS data and find positive associations between firms' perceptions of obstacles and their innovation propensity (Iammarino et al., 2009). Along the same lines, other studies (e.g. Baldwin and Lin, 2002; Galia and Legros, 2004) find that innovative firms report more frequent obstacles to innovation. In addition, obstacles should not be interpreted as preventing innovation, but rather

as indicators of how successful the firms are at overcoming them (Baldwin and Lin, 2002; Tourigny and Le, 2004). According to Iammarino et al. (2012), policies to address this issue should be directed at the micro-level and be related to a better management of innovation activity in order to minimise the impact of innovation barriers.

Thirdly, comparison of the contribution of innovation on firm performance, proxied by firm productivity, is assessed in the knowledge exploitation activity. Evidence suggests that there is no single positive and significant contribution in terms of the link between product innovation and firm performance, and between innovation success and firm performance in either country. This may suggest that the firms in both countries should pay attention to using more diverse sources and to increasing networking to acquire broader and better knowledge. For example, formally cooperating with science institutions is recommended since there is no evidence of such cooperation in both countries. As suggested by Tödtling et al. (2009, p.59), "firms introducing more advanced innovations are relying to a higher extent on R&D and patents, and that they are cooperating more often with university and research organisations". For Indonesian firms, strengthening firm resources is also recommended to improve the firms' absorptive capacity.

Evidence also shows that different types of innovation make different contributions to firm performance. In Indonesian firms, both process innovation and organisational innovation make positive contributions to firm performance, while only process innovation contributes in UK firms.

4.5.1. Innovation strategy and policy implication

Based on the study findings, relevant innovation strategy and policy can be proposed with the hope it can be implemented to strengthening the IVC in both Indonesia and the UK. A common innovation strategy that may relevant for both countries is fostering open innovation in order to facilitate and sustain open knowledge creation that often involve many actors such as firms, market/commercials, research institutes, universities, and etc.

At the firm level, the findings in the first and the second links in the IVC may have innovation strategy implication that need to be addressed by the firms' managers. The absence of science institutions networks in the firms' knowledge sourcing activity may indicate the firms in both countries seem to source knowledge from 'more conventional' knowledge such as internal R&D and market/commercials such as suppliers and customers. For the UK firms this confirms a previous study conducted by Laursen and Salter (2004) stating that only a limited number of UK firms that source directly information from universities. This suggests the firms' managers need a broader portfolio of knowledge sourcing activity by accessing better quality and more scientific source of knowledge such as universities and public/government R&D with the hope that such input of innovation can be transferred into higher novelty of innovation and then contribute to better firm performance.

For Indonesian firms, promoting and encouraging the firms to source more informal knowledge that has been proved positively contribute to innovation may an efficient way for the firms that lack of resources. In addition, a lesson learned from their counterparts in the UK may be drawn i.e. performing formal cooperation with diverse external networks may useful for the firms to support greater level of positive impact on innovation and innovation success. In this case, government intervention to promote and facilitate a triple helix strategy that involve business, universities and government cooperation may an appropriate solution. Another form of government intervention is facilitating private sectors to perform R&D activities (e.g. R&D tax credit) with the hope the private sectors will be the main R&D performer in the future.

Key findings in the last link in the IVC is also show similarities and differences between the two countries. Product innovation new to the market and new to the firms as well as innovation success have no positive impact on firm performance in both countries. This striking finding need to be addressed by the firm managers. Both process and organisational innovation positively contribute to firm performance in Indonesia, while only process innovation that positively impact UK firms' performance. Fixing the portfolio of knowledge sourcing activity may lead to better quality of innovation that able to disrupt markets then this may lead to better firm performance.

4.5.2. Limitation of the study

Lastly, limitations of this study are discussed to facilitate better studies in the future. *First,* a comparison of the IVC between Indonesia and the UK that comes from non-CIS and CIS countries may affect the comparison due to sectoral coverage, size thresholds, the length of reference periods, sampling methods and units of analysis (Bloch and Lopez-Bassols, 2009). Therefore, a comparative study of the IVCs among developing countries (ASEAN countries) should be conducted in the future for better and more comparable IVC insights. *Second,* a longitudinal study that involves more than one innovation survey period is recommended in the future to capture the dynamics of IVC. *Third,* a future study that involves both manufacturing and service firms may be conducted to portray the IVC comparison between different firms' sectors.

CHAPTER 5 DISCUSSION AND CONCLUSIONS

5.1 Introduction

Chapter 5 provides a summary, discussion and conclusions of this thesis that consists of three papers. The next section summarises and provides key findings of each paper of this thesis. Then, the empirical and practical implications of each paper is discussed. Lastly, limitations of this thesis and future research directions are suggested.

5.2 Summary of the Study

This section summarises the three papers of this thesis that consists of objectives, research questions, hypotheses and key findings of the three papers.

5.2.1. Chapter 2 - The first paper

This study aims to identify and to compare different knowledge sourcing strategies (KSS) and innovation barriers across manufacturing firms in 53 high-income (HI) and middle-income (MI) countries by using the UNESCO institute of statistic (UIS) global innovation data that was launched in 2013. In this study, KSS is defined as "a firm's approach to generating incoming knowledge flows through knowledge creation or knowledge acquirement" (Wen Lin and Hung Wu, 2010, p.582). A research question that is addressed in this study is: *"What is the difference in KSS performed, and innovation barriers faced, by manufacturing firms across HI and MI countries?"* Findings of this study are expected to contribute to the empirical evidence on the linkage between KSS to innovation barriers that to date such evidence is relatively few. Important policy implications of this study are the design of future innovation policy and strategy that may useful to address hampering factors related to KSS that prevent manufacturing firms across HI and MI countries from engaging in innovation activities. Hypotheses that are addressed in this study are as follows:

H1a Manufacturing firms in HI countries make more use of internal R&D than firms in MI countries.

H1b Manufacturing firms in MI countries make more use of external knowledge sources than firms in HI countries.

H2 Manufacturing firms in MI countries face higher levels of innovation barriers than those in HI countries.

Table 5.1 summarises key findings of this study. Three main issues that are compared between manufacturing firms in HI and MI countries are KSS, innovation barriers and innovation outputs.

Table 5.1 Summary of the study findings

	HI countries	MI countries
Knowledge sourcing strategy		
Internal R&D	**High*** **	Low
Public R&D (GERD)[1]	**High*** **	Low
Ext. knowledge-Suppliers	No difference	No difference
Ext. knowledge-Customers	No difference	No difference
Ext. knowledge-Competitors	No difference	No difference
Ext. knowledge-Consultants	No difference	No difference
Ext. knowledge-Universities	No difference	No difference
Ext. knowledge-Research Institutions	Low	**High** **
Ext. knowledge-Events	Low	**High** **
Ext. knowledge-Publications	Low	**High** *
Ext. knowledge-Associations	No difference	No difference
Innovation barriers		
Internal funding	Low	**High*** **
External funding	Low	**High** *
High cost	Low	**High** *
Personnel	No difference	No difference
Information on technology	Low	**High*** **
Information on market	Low	**High*** **
Cooperation	Low	**High*** **
Market domination	Low	**High*** **
Uncertain demand	Low	**High** *
Prior innovation	Low	**High*** **
No demand	Low	**High*** **
Innovation outputs		
Product innovation	No difference	No difference
Process innovation	No difference	No difference
Number of patent	**High*** **	Low

Note: The results are based on the non-parametric Mann Whitney-U (MWU) test on significant median difference. Significant levels *p≤.10, **p≤.05, ***p≤.001. [1]GERD is *Countries' (public) R&D expenditure as % of GDP that is derived from World Development Indicator 2010, the World Bank*

Table 5.1 clearly shows that manufacturing firms in HI and MI countries have different direction of KSS. The firms in HI countries tend to source knowledge from internal R&D higher than their counterparts in MI countries and therefore H1a is supported. By contrast, the firms in MI countries are more likely to source knowledge from external (e.g. government/public research institutions, events and scientific publication) higher than the firms in HI countries and therefore H1b is also supported.

In terms of innovation barriers, the study shows that firms in MI countries face greater innovation barriers internally and externally than those in HI countries. Internally, manufacturing firms in MI countries face greater obstacles related to *cost and funding* (e.g. lack of internal funding, high cost of innovation); *knowledge* (e.g. lack of information on technology and market, and no need to innovate due to prior innovation has been performed). Externally, the firms in MI countries faced greater constraints related to

cost and funding (e.g. lack of external funding to support innovation); *knowledge* (e.g. difficulty in finding cooperation partners), *market* (e.g. established firms dominated market, uncertain demand for innovative products), and *other reason for not innovating* (e.g. no demand for innovation) than their counterparts in HI countries. Hence, hypothesis H2 can be supported. In the case of innovation outputs, only patent that differentiate between the firms in HI and MI countries i.e. the firms in HI countries produce more patent than their counterparts in MI countries.

5.2.2. Chapter 3 - The second paper

This study aims to investigate and to model the IVC that encompasses knowledge sourcing, transformation and exploitation activities of Indonesia manufacturing firms by using data from the Indonesia Innovation Survey (IIS) 2011. Research questions related to the IVC activities that are addressed in this study are as follows:

1. To what extent are the various knowledge sources used by Indonesian manufacturing firms?
2. To what extent are the various knowledge sources used in the knowledge transformation activities associated with diverse types of innovation?
3. To what extent do the different types of innovation adopted by Indonesian manufacturing firms influence firm performance (that is proxied by productivity)?

5.2.2.1. Knowledge sourcing activity

In the first link in the IVC, knowledge from various sources inside and across the firm units or outside the firms are sourced (Hansen and Birkinshaw, 2007) and therefore the main firm task in this activity is to assemble the bundle of different knowledge use for innovation (Roper et al., 2008). Here, main interest that is investigated is synergistic or substitution relationship between sources of knowledge. Therefore, in the first link of IVC, a hypothesis that is addressed is as follow:

H1 In knowledge sourcing activities, synergistic relationship exists between internal R&D and external sources of knowledge.

Table 5.2 summaries relationship symbolic in the knowledge sourcing link. Positive and negative figures are resulted from marginal effects generated from Probit models. Positive (+) marks mean positive and significant relationships between knowledge sources and indicate synergistic or complement relationships, while negative (-) marks show negative and significant relationships between knowledge sources and indicate that the knowledge sources are substituted. The table clearly shows that synergistic relationships exist within and between group source of knowledge. Therefore, based on this, hypothesis 1 is supported. In R&D group, there is no synergistic relationship between external R&D and other external knowledge from market and commercials as well as open sources. In informal knowledge group, synergistic relationships tend to exist among market/commercials networks; between market/commercial networks and

associations; and between market/commercial networks and open sources. By contrast, few synergistic relationships between science institutions and other external knowledge links. Lastly, synergistic relationships also can be found between associations and other external knowledge; and between open sources and other external knowledge. In formal cooperation group, only cooperation activities performed by firm group and suppliers tend to have synergistic relationships with other source of knowledge.

Table 5.2 Symbolic summary - Knowledge sourcing activity (The IIS 2011)

MODELS

R&D ACTIVITIES

	IN RD	EX RD	SUPP	CUS	COM PET	CON SUL	COM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
INTERNAL_R&D		+		+	+		+	+					+	+			+
EXTERNAL_R&D	+										+	+					

INFORMAL KNOWLEDGE

Market/Commercials	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COMM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
SUPPLIERS							+										
CUSTOMERS	+				+	-					+	+		+	+	+	+
COMPETITORS				+		+							+	+	+		
CONSULTANT				-	+		+						+				+
COMMLAB			+			+		+		+						+	
Science	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COMM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
UNIVERSITIES	+						+		+	+		+	+			-	
POLYTECHNIC								+		+		-		+		+	
GOV_RD		-					+	+	+		+	+					
NONPROFIT_RD		+		+					+	+			+				
Associations	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COMM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
INVESTORS		+						+		+			+	+	+		
IND_ASSOC						+		+			+	+		+	+		+
ENTREP.	+			+	+							+					
Open sources	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COMM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
EVENTS				+	+											+	
SCIENCE_PUB				+			+		+		+		+	+	+		+
INTERNET	+			+		+				+			+				

FORMAL COOPERATION

Market/commercials	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
COOP_GROUP	+	+		+			+							+	+	+	

COOP_SUPPLIERS	+	+	+									+		+			+
COOP_COMPET					+												
COOP_CONSUL						+	-	-									
COOP_COMMLAB					+	+											-
Science	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
COOP_UNIV			-					+			+				+		
COOP_GOVRD			+							+							+
Association	IN RD	EX RD	SUPP	CUS TOM	COM PET	CON SUL	COM LAB	UNIV	POL TECH	GOV RD	NPROF RD	INVES TORS	IND ASSO	ENTREP	EVENT	PUB	INTER NET
COOP_INDASSOC.	+												+				

Notes: The results are based on marginal effects a series of Probit regressions. Significant levels *p≤.10, **p≤.05, ***p≤.001. IN_RD (internal R&D), EX_RD (external R&D), SUPP (suppliers), CUSTOM (customers), COMPET (competitors), CONSUL (consultant), COMMLAB (commercial labs), UNIV (universities), POLTECH (polytechnic), GOV_RD (government R&D), NONPROF_RD (non-profit R&D), INVESTORS, IND_ASSOC (industry association), ENTREP (entrepreneurs), EVENTS, PUB (science publication), INTERNET

5.2.2.2. Knowledge transformation activity

In the second link of the IVC, different sources of knowledge use in the innovation activities are transformed or converted into different types of innovation (Hansen and Birkinshaw, 2007; Roper et al., 2008). Therefore, the main issue addressed in this stage is the empirical assessment of the comparative impact of different sources of knowledge (i.e. R&D activities, informal knowledge and formal cooperation) on different types of innovations (product, process, organisational, and marketing) and innovation success. Apart from three sources of knowledge, the influence of external knowledge breadth (BREADTH) and innovation barriers on innovation and innovation success are also tested. In the second link of IVC, the hypotheses that are addressed are as follows:

H2a Internal R&D positively influence innovation and innovation success.

H2b Different levels of informal knowledge and formal cooperation influence innovation adoption differently.

H2c Innovation barriers encountered by firms negatively affect innovation and innovation success.

Table 5.3 display the summary of symbolic relationships in the knowledge transformation link. Positive (+) marks indicate positive and significant impacts of independent variables on dependent variables, by contrast, negative (-) marks shows negative and significant direction of impacts. The table shows that in general, internal R&D is consistently, positively and strongly effect innovation and innovation success. By contrast, external R&D has no positive and significant impact on innovation and innovation success. Based on this, hypothesis H2a is supported. Of individual informal knowledge (i.e. customers, competitors and events) have greater positive impact on innovation and innovation success than other informal source of knowledge. In formal cooperation group, only formal cooperation with suppliers that significantly and positively impact innovation and innovation success. Hence, it may be summarised that informal and formal knowledge affect innovation and innovation success differently and as a result hypothesis H2b is supported. In terms of innovation barriers, individually, constraint has different direction of impact on innovation and innovation success i.e. positive and negative impacts. Four innovation barrier groups as the outcomes of factor analysis also shows positive and negative impacts. Based on these findings, hypothesis H2c partially is supported.

Table 5.3 Symbolic summary - Knowledge transformation activity (The IIS 2011)

INDEPENDENT VARIABLES	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
R&D ACTIVITIES							
INTERNAL_RD	+	+	+	+	+	+	+
EXTERNAL_RD							
INFORMAL KNOWLEDGE							
Market/Commercials	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
SUPPLIERS							
CUSTOMERS	+		+			+	+
COMPETITORS		+		+		+	
CONSULTANT							
COMMLAB							
Science	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
UNIVERSITIES				-			
POLYTECHNIC				-			
GOVERNMENT_RD				+			
NONPROFIT_RD				+			
Associations	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INVESTORS			+	+			
INDUSTRY_ASSOC		-	-				
ENTREPRENEURS	-						-
Open resources	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
EVENTS	+	+	+				+
SCIENCE_PUB							
INTERNET							
BREADTH	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS

BREADTH	+	+	+	+	+	+	+
$BREADTH^2$	-	-	-	-	-	-	-
FORMAL COOPERATION							
Market/Commercials	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
COOP_GROUP							
COOP_SUPPLIER	+		+			+	+
COOP_COMPET						-	
COOP_CONSUL	-		-				
COOP_COMMLAB							
Science	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
COOP_UNIV							
COOP_GOVRD							
Association	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
COOP_INDASSOC.							
INNOVATION BARRIERS							
Financial constraints	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INBAR_INFUND							
INBAR_EXFUND		-			+	+	
INBAR_COST					-		
INBAR_RISK							
Knowledge constraints	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INBAR_STAFF	+	+					
INBAR_MANAGER		+					+
INBAR_ORGINN						+	
INBAR_PERSON		-					-
INBAR_TECHINFO							

INBAR_MKTINFO							
INBAR_COOP.		-				+	-
INBAR_LABOUR						-	
Market constraints	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INBAR_MKTDOM							
INBAR_UNCERDEMD							
INBAR_CUSTOMER				-			
Institution constraints	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INBAR_INFRA.		-	-	+			-
INBAR_INDUSTRY							
INBAR_GOVREG							
GROUPS OF INNOVATION BARRIERS							
	PROD INOV	PRODINOV NEW2MKT	PRODINOV NEW2FIRM	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
Market & institutions					-		
Financial & risk		-			-		
Employee & organisation		+					+
Knowledge & cooperation			+				-

Notes: The results are based on marginal effects a series of logit regressions (dependent variables are types of innovation) and tobit regression (dependent variable is innovation success). Significant levels *p≤.10, **p≤.05, ***p≤.001. PRODINOV (product innovation); PRODINOV_NEW2MKT (product innovation new to the market); PRODINOV_NEW2FIRM (product innovation new to firm); PROCINOV (process innovation); ORGINOV (organisational innovation); MKTGINOV (marketing innovation); INNOVSUCCESS (innovation success: sales' proportion of product innovation new to the market)

5.2.2.3 Knowledge exploitation activity

The final link in the IVC is knowledge exploitation that generates value for the firm. The main interest in this stage is how firms gain productivity from the exploitation of adopted innovation. In this study, productivity (indicated by total sales/number of employees) is used to measure how innovation affects overall firms' performance. A hypothesis that is addressed in the last link of IVC is as follow:

H3 In knowledge exploitation activity, innovation and innovation success positively affects a firm's performance.

Table 5.4 presents symbolic summary of knowledge exploitation link and it shows that innovation outputs such as product and organisational innovation positively and significantly impact firm performance (i.e. productivity). Surprisingly, product innovation that new to the market and new to the firms as well as innovation success have no positive impact on productivity. Based on this, it may be concluded that hypothesis H3 is partially supported.

Table 5.4 Symbolic summary - Knowledge exploitation activity (The IIS 2011)

INDEPENDENT VARIABLES	PRODUCTIVITY (Sales/number of employee)		
PRODINOV			
PRODINOV_NEW2MARKET			
PRODINOV_NEW2FIRM			
PROCINOV	+	+	+
ORGINOV	+	+	+
MKTGINOV	-	-	-
INNOVSUCCESS[1]			

Notes The results are based on a series of OLS regressions. Positive (+) marks indicate positive and significant impacts of independent variables on dependent variables, by contrast, negative (-) marks show negative and significant direction of impacts. Significant level $p \leq .001$. [1]Innovation success: sales' proportion of product innovation new to the market.

5.2.3 Chapter 4 - The third paper

This study aims to compare the IVC that consist of three main links such as knowledge sourcing, transformation and exploitation performed by manufacturing firms in Indonesia and the UK. A research question that is addressed in this study is "to what extent knowledge sourcing, transformation and exploitation are performed differently by Indonesia and the UK manufacturing firms?".

In this study, sources of knowledge are grouped into R&D activities (i.e. internal and external R&D), informal knowledge (e.g. suppliers, customers, competitors, consultant, universities, government R&D, industry associations, events and science publication), and formal cooperation (e.g. firm group, suppliers, competitors, consultant, universities and government R&D). In addition, informal knowledge can be sub divided into *market/commercials* (e.g. suppliers, customers, competitors, consultant), *science institutions* (e.g. universities, government R&D), *association* (e.g. industry association), and *open sources* (e.g. events and science publication).

5.2.3.1. Knowledge sourcing activity

In the first link in the IVC, different sources of knowledge from internal and/or external firms (i.e. R&D, informal knowledge and formal cooperation) are sourced (Hansen and Birkinshaw, 2007, Roper et al., 2008). The main interest in this link is to investigate the existence of synergistic or substitution relationship among R&D, informal knowledge and formal cooperation between Indonesia and the UK firms. Therefore, the following hypothesis is tested:

H1 In the knowledge sourcing activity, synergistic relationships between internal R&D and external knowledge and among external knowledge exist in both Indonesian and UK firms

Table 5.5. compares the symbolic summary of knowledge sourcing link between Indonesia and UK firms. Positive (+) marks mean positive and significant relationships between knowledge sources and indicate synergistic or complement relationships, while negative (-) marks show negative and significant relationships between knowledge sources and indicate that the knowledge sources are substituted. The table clearly shows a synergistic relationship between internal and external R&D. In addition, such relationships also exist between internal R&D and external knowledge from market/commercials and open sources. In terms of informal knowledge, the table shows synergistic relationships among market/commercials networks; between market/commercials agents and associations; and between market/commercials agents and open sources for both countries. In the case of formal cooperation, the two countries show different direction of relationship. For Indonesia, synergistic relationships tend to exist between firm group and other external sources of knowledge (except science institutions) and between suppliers and both internal and external R&D. By contrast, the synergistic relationships in the UK firms involve a wider formal cooperation partners than in Indonesia firms. Hence, based on this, H1 is supported.

Table 5.5 Symbolic summary of knowledge sourcing activity – The IIS 2011 & THE UKIS 2011

	THE IIS 2011											THE UKIS 2011										
R&D ACTIVITIES																						
	IN RD	EX RD	SUP	CUS TOM	COM PET	CON SUL	UNI	GOV RD	IND ASSO	EVE NTS	SCI PUB	IN RD	EX RD	SUP	CUS TOM	COM PET	CON SUL	UNI	GOV RD	IND ASSO	EVE NTS	SCI PUB
INTERNL_RD		+		+	+	+	+		+	+			+	+	+	+						+
EXTERNL_RD[6]	+											+					+					
INFORMAL KNOWLEDGE																						
Mkt/Commercial	IN RD	EX RD	SUP	CUS TOM	COM PET	CON SUL	UNI	GOV RD	IND ASSO	EVE NTS	SCI PUB	IN RD	EX RD	SUP	CUS TOM	COM PET	CON SUL	UNI	GOV RD	IND ASSO	EVE NTS	SCI PUB
SUPPLIERS												+			+	+	+			+		
CUSTOMERS	+				+				+	+	+	+	+	+		+		+		+	+	
COMPETITORS	+			+		+				+				+	+		+			+	+	+
CONSULTANT	+				+		+	+	+		+		+	+		+		+	+			
Sciences																						
UNIVERSITIES						+		+	+						+		+		+			
GOV_RD		-				+	+		+	+			-				+	+		+	+	
Associations																						
IND_ASSOC	+			+		+	+	+		+				+	+	+			+		+	+
Open sources																						
EVENTS				+	+			+	+		+				+	+	+		+	+		+
SCIENCE_PUB				+		+			+	+		+								+	+	
FORMAL COOPERATION																						
	IN RD	EX RD	SUP	CUS TOM	COM PET	CON SUL	UNI	GOV RD	IND ASSO	EVE NTS	SCI PUB	IN RD	EX RD	SUP	CUS TOM	COM PET	CON SUL	UNI	GOV RD	IND ASSO	EVE NTS	SCI PUB
COOP_GROUP	+	+		+		+			+	+	+	+	+		+	+		-		+	+	
COOP_SUPP.	+	+										+	+	+	+	+						
COOP_COMPET					+											+		+		+		+
COOP_CONSUL						+	-					+	+	+	+	+	+			+	+	+

[6] External R&D in this study is grouped in R&D activities along with internal R&D, however, based on the degree of externalisation, external R&D, informal and open networks, and cooperation activities 'are external to the enterprise to various degrees, depending on their ownership and the contractual structures of the relationship between our enterprise and the other party or parties to the transfer' (Frenz and Ietto-Gillies, 2009, p. 1126).

COOP_UNIV.							+					+	+		+			+				
COOP_GOVRD								+				-	-						+			

Notes: The results are based on marginal effects a series of Probit regressions. Significant levels *p≤.10, **p≤.05, ***p≤.001. IN_RD (internal R&D), EX_RD (external R&D), SUP (suppliers), CUSTOM (customers), COMPET (competitors), CONSUL (consultant), UNIV (universities), GOV_RD (government R&D), IND_ASSOC (industry association), EVENTS, SCIPUB (science publication)

5.2.3.2. Knowledge transformation activity

In the second link in the IVC, knowledge inputs (i.e. R&D, informal knowledge and formal cooperation) is transformed to form innovation outputs and this link in line with innovation or knowledge production function (Griliches, 1992; Love and Roper, 1999). The main interest in this link is the impact of different knowledge inputs on technological innovation (i.e. product and process innovations), non-technological innovations (i.e. organisational and marketing innovations) and innovation success in both Indonesia and the UK firms. The followings are hypotheses addressed in the second link of the IVC:

H2a The impact of both internal and external R&D on technological and non-technological innovations more strongly and positively impacts UK firms than Indonesian firms.

H2b Innovation in Indonesian firms is more strongly and positively impacted by informal knowledge than innovation in UK firms.

H2c External knowledge breadth has a positive impact on innovation for both Indonesian and UK firms

H2d Indonesian firms face a stronger and a greater variety of innovation barriers than UK firms

Table 5.6 summaries symbolic of the knowledge transformation links for both Indonesia and the UK. Positive (+) marks indicate positive and significant impacts of independent variables on dependent variables, by contrast, negative (-) marks shows negative and significant direction of impacts. It can be seen that the impact of external R&D on innovation and innovation success is different between the two countries, while internal R&D in both Indonesia and the UK firms has consistent, positive and strong impact on innovation and innovation success. Therefore, hypothesis 2a (H2a) is partially supported. In terms of informal knowledge, Indonesia has broader and different types of knowledge that positively and significantly impact innovation and innovation success than the UK. In this case hypothesis 2b (H2b) is supported. Knowledge from science institutions (e.g. universities and government R&D) in both countries tend to have no impact on innovation and innovation success. External knowledge breadth (BREADTH) in both countries has positive and significant impact on innovation and innovation success. Therefore, hypothesis 2c (H2c) can be supported. The impact of formal cooperation on innovation is different for Indonesia and the UK. In the case of Indonesia, only cooperation with suppliers that positively and significantly influence innovation, while formal cooperation in the UK has broader positive impact on innovation. In terms of innovation barriers, Indonesia and the UK firms face positive and negative associations between the barriers and innovation. However, Indonesia has more positive associations between barriers and innovation than negative associations, and therefore it is difficult to conclude that Indonesian firms face greater innovation barriers than the UK firms. Hence, hypothesis 2d (H2d) is not supported.

Table 5.6 Symbolic summary of knowledge transformation activity-The IIS 2011 and THE UKIS 2011

	THE IIS 2011							THE UKIS 2011						
R&D ACTIVITIES														
	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INTERNAL_RD	+	+	+	+	+	+	+	+	+	+	+	+	+	+
EXTERNAL_RD		+		+	+			+	+	+				+
INFORMAL KNOWLEDGE														
Market & Commercials	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
SUPPLIERS	-										+	+	+	
CUSTOMERS	+	+	+	+	+	+	+	+	+	+	+			+
COMPETITORS		+	+	+		+	+							
CONSULTANT	+		+											
Sciences														
UNIVERSITIES				-										
GOV_RD				+										
Associations														
IND_ASSOCIATION		-						-	-	-				-
Open sources														
EVENTS	+	+	+				+		+		+			+
SCIENCE_PUB					-									
Ext. knowledge breadth														
BREADTH	+	+	+	+	+	+	+	+	+	+	+	+		
$BREADTH^2$	-	-	-	-	-	-	-		-		-	-		
FORMAL COOPERATION														
	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
COOP_FIRMGROUP								+		+	+	+		
COOP_SUPPLIER	+	+	+			+	+	+	+	+	+	+	+	+
COOP_COMPETITOR			-			-		+	+	+			+	+

COOP_CONSULTANT					+		-					+	+	
COOP_UNIVERSITIES				+							+			
COOP_GOVRD		-			-									
INOVATION BARRIERS														
Financial barriers	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS	PROD INOV	NEW2 MKT	NEW2 FIMR	PROC INOV	ORG INOV	MKTG INOV	INNOV SUCCESS
INBAR_HIGHRISK	+	+			-	+	+							
INBAR_HIGHCOST				+				+						
INBAR_INFUND			+											
INBAR_EXFUND		-			+	+								
INBAR_ECONRISK									-					-
INBAR_COSTFIN														
INBAR_FINAVAILABLE														
Knowledge barriers														
INBAR_PERSONNEL								+		+				
INBAR_TECHINFO								-		-				
INBAR_MARKETINFO					-								+	
Market barriers														
INBAR_MARKETDOM				+	+	+		-	-		-			
INBAR_UNDEMAND												-		
Institution barriers														
INBAR_GOVRD														

Notes: The results are based on marginal effects a series of logit regressions (dependent variables are types of innovation) and tobit regression (dependent variable is innovation success). Significant levels *p≤.10, **p≤.05, ***p≤.001. PRODINOV (product innovation); PRODINOV_NEW2MKT (product innovation new to the market); PRODINOV_NEW2FIRM (product innovation new to firm); PROCINOV (process innovation); ORGINOV (organisational innovation); MKTGINOV (marketing innovation); INNOVSUCCESS (innovation success: sales' proportion of product innovation new to the market)

5.2.3.3. Knowledge exploitation activity

In the final link of IVC, the impact of both technological innovation (e.g. product and process innovation) and non-technological innovation (e.g. organisational and marketing innovation) on Indonesia and UK firms' productivity are assessed. A hypothesis that is addressed in the last IVC link is as follow:

H3 In Indonesian firms, both technological and non- technological innovation have positive impact on productivity, while in UK firms only technological innovation has a positive impact on productivity.

Table 5.7 compares the symbolic summary on knowledge exploitation activity between Indonesia and the UK manufacturing firms. Positive (+) marks indicate positive and significant impacts of independent variables on dependent variables, by contrast, negative (-) marks show negative and significant direction of impacts. In Indonesia, technological (i.e. process innovation) and non-technological (i.e. organisational innovation) innovation contribute to positive impact on productivity, while for the UK only technological innovation (i.e. process innovation) that has similar contribution.

Table 5.7 Symbolic summary of knowledge exploitation activity
(The IIS 2011 and The UKIS 2011)

INDEPENDENT VARIABLES	Productivity (IIS 2011)		Productivity (UKIS 2011)	
PRODINOV				
PRODINOV_NEW2MARKET				
PRODINOV_NEW2FIRM			-[2]	
PROCINOV	+	+	+	+
ORGINOV	+	+		
MKTGINOV	-	-		
INOVSUCCESS[1]			-[2]	

Notes: The results are based on a series of OLS regressions. Significant level p≤.001 (except for [2], significant level p≤.10). Positive (+) marks indicate positive and significant impacts of independent variables on dependent variables, by contrast, negative (-) marks show negative and significant direction of impacts. [1]Innovation success: sales' proportion of product innovation new to the market.

5.3. Conclusion and Implications of the Study

This section discusses empirical contributions and relevant innovation strategy and policy implications drawn from each paper in chapters 2 to 4.

5.3.1. Chapter 2 - The first paper

This study provides new empirical evidence at country level on the link between KSS, innovation barriers, and innovation outputs across manufacturing firms in high-income (HI) and middle-income (MI) countries. Previous similar studies tend to employ innovation data at firm level and focus on a single country (e.g. Fu et al., 2015, Keupp and Gassmann, 2009) and therefore this study intends to close this gap by identifying and comparing different KSS and innovation barriers by using the UNESCO institute of statistic (UIS) global innovation data that was launched in 2013.

Three key findings from this study can be summarised as follows. First, in terms of KSS, the firms in HI countries make more use internal R&D than their counterparts in MI countries, by contrast, the firms in MI countries make more use external knowledge (e.g. government/public research institutes, events, and scientific publications) than their counterparts in MI countries. In addition, HI countries invest higher proportion of public R&D (GERD) than MI countries. Second, the firms in MI countries face greater level of both internal and external innovation barriers than the firms in HI countries. Third, the firms in HI countries produce higher number of patent as the indicator of innovation output than the firms in MI countries. While, there is no different on the proportion of product and process innovation between the firms in HI and MI countries.

Further study result is that based on scatter plots analysis on KSS, the firms in both HI and MI countries can be grouped into four different KSS. First, internal KSS or closed innovation in which the firms tend to generate knowledge from internal R&D. This KSS tend to be implemented by the firms in HI countries such as Belgium, Finland, Korea and Netherlands. While, examples from MI countries such as Indonesia and Serbia. Second, integration KSS or open innovation strategy where the firms tend to balance between generating knowledge from internal R&D and sourcing knowledge from external actors. The firms in the following countries such as Luxembourg, China and Malaysia tend to implement this strategy. Third, external KSS in which the firms tend to source knowledge from external higher than internal. The firms in Cyprus, New Zealand, and Columbia tend to be implemented this strategy. Fourth, innovation laggard where both internal R&D and external knowledge are sourced low by the firms. Examples of the countries that their firms tend to perform this strategy are Australia and Panama.

Further discussion on the association among knowledge sourcing strategy, innovation barriers and innovation output may be drawn. The first key finding in line with majority previous studies that use firm level data. The higher level of economic development of the countries, the greater intensity of the firms operating in such countries to perform internal R&D (e.g. Acemoglu et al., 2006; Battisti et al., 2014; Hobday, 2005; Hölzl and Janger, 2014). This study also suggests that the higher proportion of internal R&D and public R&D investment, that is also supported by lower level of innovation barriers lead to higher level of number of patents. This may indicate that instead of sourcing from external knowledge, more traditional internal sources of R&D are the main knowledge inputs used by innovation leaders (i.e. the firms in HI countries) and this lead to higher production of patents. This finding confirms previous studies that show positive links between internal R&D and innovation and productivity in both developed economies (e.g. Griffith et al., 2004; Griffith et al., 2006; Mohnen et al., 2006) and developing economies (e.g. Chudnovsky et al., 2006; Hegde and Shapira, 2007; Jefferson et al., 2006; Yan Aw et al., 2008).

It is suggested that internal R&D is essential for innovation followers to the “absorptive” or “national learning” capacity required to exploit advanced technology from advanced countries (Goñi and Maloney, 2014). In addition, the return from performing R&D for developing countries is higher than technological

frontiers (Goñi and Maloney, 2014). An interesting finding from this study is despite closed-KSS or internal R&D has been performed more intense by few MI countries (including Indonesia) than other MI countries, however the strategy does not lead to higher number of patent. Possible reasons to explain this phenomenon are as follows. First, the firms in the innovation followers face greater level of both internal and external constraints than the firms in innovation leaders. Second, a country's overall system such as universities, private sector research departments, and higher level of human capital affect quality of R&D (Nelson, 2005; Rosenberg, 2000).

This study also suggests that for the firms in MI countries intend to catch-up with technology frontiers, the case of China shows that integration KSS leads to the high number of patents[7]. Although there is no measurement on external search breadth and depth as the common open innovation indicators using innovation survey data (e.g. Laursen and Salter, 2006) in this study, integration KSS performed by the Chinese firms may indicate open innovation strategy. This lesson learned is derived from China as the firms in the country source higher proportion of internal R&D as well as public R&D investment than other MI countries. The Chinese firms are also tend to source knowledge from external sources to a greater extent than their counterparts in MI countries. Such efforts lead the country to produce higher number of patent than other MI countries. This is in line with previous studies indicating that Chinese firms have widely implemented an open innovation approach to develop their technological capabilities to catch-up with technological frontiers (e.g. Chen et al., 2011; Wang et al., 2011) and the studies also suggest that an open innovation approach may also be relevant for developing countries to build up technological capabilities for technological-lagging firms. Furthermore, the Chinese government has introduced strategies and policies such as acquisition of foreign technology, industry-university collaboration and the 'go-global' strategy to encourage the firms to adopt open innovation model (Fu and Xiong, 2012). In this case, China may be classified as the innovation challenger.

In relation to external knowledge, for innovation followers, it is recommended to acquiring and using existing knowledge from advanced countries through global knowledge from trade, foreign direct investment, technological licensing, copying and reverse engineering because such strategy is less costly and risky (Dahlman, 2010). However, previous scholars (e.g. Acemoglu and Zilibotty, 2001; Basu and Weil, 1998) argue that translating advanced technology from industrialised countries to developing countries is not an easy task due to different technologies presently applied or skilled mismatch.

Based on the aforementioned discussion, the following questions may arise: which KSS is suitable to be implemented for each country group?. A further question related to the implementation of integration KSS or open innovation also may arise does the strategy fits for all developing or catching-up economies? Based on lesson learned from Chinese experiences, integration KSS seems promising strategy for the firms in MI countries. However, picking an open innovation for innovation followers may be more challenging

[7] See scatter plot in the figure 18 in chapter 2 (paper 1) for innovation output (patent)

due to the firms tend to face greater internal and external constraints than the innovation leaders. According to Karo and Kattel (2011, p. 90) “the debate and strategic direction advocated by open innovation is largely conditional i.e. dependent on specific characteristics of the firm level and the wider socio-economic context”.

In terms of innovation policy implication, findings of this study may lead to the contribution of innovation policy formulation relate to KSS decisions that consider firm capabilities, constraints, and innovation outputs. However, relying on innovation data at country level may not sufficient to formulate a good and precise innovation policy. Therefore, a further global comparative study by using cross-country innovation data at firm level may provide better insight on KSS, innovation barriers and innovation issues.

5.3.2. Chapter 3 - The second paper

This study contributes to the extension and development of the innovation value chain (IVC) concept that consists of knowledge sourcing, transformation and exploitation in the context a developing country (i.e. Indonesia) by using data derived from Indonesia innovation survey 2011. Previous innovation survey-based IVC studies were conducted in developed countries empirical setting (e.g. Battisti and Stoneman, 2013; Doran and O'Leary, 2011; Ganotakis and Love, 2012; Love et al., 2011; Roper et al., 2008; Roper and Arvanitis, 2012). Key findings of this study provide new insights on inter-linkages or causal links between firm interaction, innovation and firm performance in a developing country context that is expected contributes to the enrichment of IVC literature as well as the relevant innovation strategy and policy implementation related to IVC. In summary, the Indonesian manufacturing firms IVC shows the causal positive links from knowledge sourcing activities (internal R&D to be complemented with customers, competitors, and formal cooperation with suppliers), through process and organisational innovation, that positively impact overall firm performance (proxied by firm productivity).

More specifically, this study contributes to the IVC literature in number of ways. First, in this study a range sources of knowledge (i.e. R&D activities, informal knowledge, and formal cooperation) is tested. Second, the relationship between a wide range of innovation barriers and the IVC is also investigated. Lastly, wider innovation i.e. organisational and marketing innovation are assessed. While, previous IVC studies tend to focus on technological innovation that consists of product and process innovation.

In knowledge sourcing activities, key result here that may differentiate the Indonesian IVC and previous IVC studies is that internal R&D is more likely to be complemented with informal knowledge (i.e. customers and competitors) and formal cooperation that mainly performed with suppliers. In this case, external knowledge from science institutions less to be sourced by the firms. There is also no indication that the Indonesian high-technology firms source knowledge from R&D. While, the existence of synergistic or complementary between internal and external knowledge confirms majority of previous IVC studies’ findings.

Key finding in the second link of the IVC (i.e. knowledge transformation activity) here that of several types of knowledge, internal R&D is consistently, positively and significantly affect both technological (i.e. product and process innovation) and non-technological (i.e. organisational and marketing innovation) innovation as well as innovation success. Insights from the majority of previous IVC studies show positive impact of internal R&D on product and process innovation, while insight on the link between internal R&D and non-technological innovation is absence (e.g. Doran and O'Leary, 2011; Ganotakis and Love, 2012; Love et al., 2011; Roper et al., 2008; Roper and Arvanitis, 2012). By contrast, external R&D has no impact on innovation and innovation success.

In the last link in the IVC, key result that may distinguish this study compared to the previous studies is that both technological (i.e. process innovation) and non-technological (i.e. organisational innovation) innovation positively contribute to overall firm performance that is measured by firm productivity. Striking findings, by contrast, higher novelty of innovation (e.g. product innovation new to the market and new to the firms) and innovation success have no positive impact on the firm performance.

Based on key findings in each link in the IVC, then innovation strategy and policy implications may be discussed. According to Hansen and Birkinshaw (2007) the IVC is a useful tool to detect any weakness in the three-main links of innovation process. In the first link of the Indonesian firms' IVC, a symptom of weakness relates to "diversity and quality" of sources of knowledge can be detected. Lack of the external knowledge linkage diversity may be found due to internal R&D tend to be complemented narrowly with informal linkage such as market/commercials networks and limited formal cooperation partners. A better quality of external knowledge networking with science institutions such as universities and public or government R&D is also less to be performed. In addition, OECD (2013, p. 175) reports that Indonesia tend to face the following challenges such as "low public and private investment in R&D", "a low-ranked higher education and training system", "small number of researchers and scientists for a country of its size".

While, problems may arise in the second link in the IVC is the unbalance of positive impact of sources of knowledge on innovation and innovation success. It turns out that only internal R&D consistently contributes to positive impact on innovation and innovation success. Only few sources of external knowledge that nearly has the same role as internal R&D (e.g. customers, competitors and events) that mainly come from informal knowledge. In the last link in the IVC, unexpected problem may exist due to the absence positive contribution of higher novelty of innovation on firm performance. This may be caused by the greater variety and negative impacts of innovation barriers on product innovation that new to the market compared than other types of innovation.

The Indonesia's IVC problems emerge from this study seem in line with problems relate to public R&D activities in Indonesia such as "lack of funding leading to difficulty in hiring qualified researchers" and "lack of ties with the private sector, resulting in R&D programmes that are not responsive to the demands of industries" (Gammeltoft and Aminullah, 2006, p. 150). In addition, "many of the public R&D

projects without involving industries, as indicated by a very limited utilization by industries of public R&D output" (Gammeltoft and Aminullah, 2006a, p. 150). Expecting transfer knowledge or technological learning from global technology spillovers may a reasonable solution, however, the contribution of FDI on Indonesian firms' technological development face serious problem in capability development (Okamoto and Sjoholm, 2001; Thee, 2005). Therefore, two main challenges in sourcing knowledge from outside local industries are: "one outside source is the public R&D institutions which tend to fail due to weak linkage to the industrial sector", "the other outside source is FDI which does not automatically generate technological capability due to weak industrial R&D infrastructure to absorb the technology" (Gammeltoft and Aminullah, 2006a, p. 150).

All the weaknesses in each the IVC link may have implication on innovation strategy and policy. From Indonesia government perspective, relevant innovation policy to address any weaknesses in the IVC links is essential. Promoting and improving the degree of university-industry collaboration as well as scientific research institutions quality may effective to access better source of knowledge. A triple helix programme that involves university-industry-government interaction and partnership may relevant to address these challenges to improve knowledge spill overs as well as the integration of the three institutions. Policy relate to financial incentive to enhance private sector innovation is also important to overcome financial barriers. In terms of internal R&D, for Indonesian firms, solely relying on industrial R&D to build technological capabilities is inadequate, therefore, innovation policy to balance local innovation and international learning is essential due to "it will improve efficiency, raise productivity, and finally strengthen financial capability and stable business growth" (Gammeltoft and Aminullah, 2006, p. 150).

To address human resource constraint, from the firm perspective, regular programs such as training, workshops and advance education to enhance employees' knowledge and skills are very important to be performed. Constraint relate to human resources that lead to a syndrome so called 'not invented here' also need to be addressed due to it may has important roles in the success of knowledge sourcing and transformation activities.

Finding from this study shows that external knowledge breadth positively impact innovation and innovation success may indicates a promising start for Indonesian firms to implement open innovation strategy as this strategy has also implemented in developing countries like China (see Chen et al., 2011; Fu and Xiong, 2012; Wang et al., 2011 for review). This also opens a new opportunity for Indonesian researchers to study open innovation in further researches.

5.3.3. Chapter 4 - The third paper

This study contributes to the comparison of the IVC that comprises knowledge sourcing, transformation and exploitation between a developing (i.e. Indonesia) and a developed (i.e. the UK) countries that has not been conducted previously. Hence this study provides the first empirical evidence on such comparison as

previous comparison studies tend to be conducted in developed economies. This study is worth conducting due to the following reasons. *First,* despite comparative study on the IVC is not new to the literature, it is interesting to understand the IVC comparison between developing and developed economies that currently does not exist. This study provides new insight on micro-level analysis on the IVC comparison between developing and developed countries in modelling which specific knowledge is sourced by the firms, what the impact of the sourced knowledge on innovation, and what the impact of innovation on the firms' productivity. *Second,* this study investigates a broader source of knowledge that is classified into R&D activities, informal knowledge and formal cooperation. Furthermore, the impact of knowledge transformation on both technological and non-technological innovation and then the exploitation of both innovation on firm performance (i.e. productivity) are tested. While previous comparative IVC studies tend to focus on internal R&D (e.g. Janz et al., 2007); internal R&D and market agents (e.g. Griffith et al., 2006); and internal R&D, public R&D and market agents (e.g. Roper and Arvanitis, 2012) as the sources of knowledge and these studies tend to measure impact of knowledge solely on technological innovation.

In summary, this study suggests that the causal link from knowledge sourcing, through innovation to firm performance between Indonesia and the UK manufacturing firms share similarities and differences. For Indonesia, internal R&D that are complemented with informal knowledge (e.g. customers and competitors) and formal cooperation with suppliers are successfully transformed into diverse types of innovation; then both process and organisational innovation positively contribute to firm performance. While for the UK, internal R&D that are complemented with external R&D and diverse formal cooperation partners are successfully transformed into different types of innovation; however only process innovation that positively impacts firm performance.

Key finding in the first link in the IVC is that strong synergistic relationships between internal and external knowledge exist in both countries. For examples, the relationships between internal and external R&D; and internal R&D and market/commercials networks. The firms in both countries also tend to lesser source knowledge from science institutions if the firms already source knowledge from internal and external R&D. However, relationship between internal R&D and formal cooperation show different direction i.e. UK firms are more likely to complement internal R&D with broader formal cooperation partners than Indonesian firms. While, the Indonesian firms tend to complement formal cooperation narrowly with the firm group and suppliers. Another distinction is that the UK exporters tend to source knowledge from internal R&D and diverse external knowledge providers as well as do more formal cooperation. While, the non-low technology UK firms are more likely source knowledge from internal R&D and science institutions.

Key results in the second link in the IVC also share similarities and differences between the firms in the two countries. Of three group of knowledges, internal R&D consistently and positively contributes to innovation and innovation success in both countries. Another similarity for both countries is that external

knowledge breadth also has positively impact on diverse types of innovation. In addition, due to the absence of scientific knowledge from external in the first link in the IVC, no surprising that very few positive impact from science institutions on innovation in the second link in the IVC in both countries. While, the impacts of external R&D and formal cooperation on innovation show different direction for both countries i.e. the UK firms have stronger impact than Indonesian firms. For Indonesia firms, informal knowledge (mainly from market/commercials networks) has greater impact on innovation than UK firms. In the link between constraints and innovation, Indonesian firms are more likely face greater number of positive constraints than UK firms, while UK firms have higher number of negative associations than Indonesia firms.

At firm level, the findings in the first and the second links in the IVC may have innovation strategy implication that need to be addressed by the firms' managers. The absence of science institutions networks in the firms' knowledge sourcing activity may indicate the firms in both countries seem to source knowledge from 'more conventional' knowledge such as internal R&D, suppliers and customers. For Indonesian firms, this finding in line with paper 2 (see chapter 3), while for the UK firms this confirms a previous study conducted by Laursen and Salter (2004) stating that only a limited number of UK firms that source directly information from universities. This suggests the firms' managers need a broader portfolio of knowledge sourcing activity by accessing better quality and more scientific source of knowledge such as universities and public/government R&D with the hope that such input of innovation can be transferred into higher novelty of innovation and then contribute to better firm performance. For Indonesia firms, a lesson learned from their counterparts in the UK may be drawn. Performing formal cooperation with diverse external networks may useful for Indonesia firms to support greater level of positive impact on innovation and innovation success.

Key findings in the last link in the IVC is also show similarities and differences between the two countries. Product innovation new to the market and new to the firms as well as innovation success have no positive impact on firm performance in both countries. This striking finding need to be addressed by the firm managers. Both process and organisational innovation positively contribute to firm performance in Indonesia, while only process innovation that positively impact UK firms' performance. Fixing the portfolio of knowledge sourcing activity may lead to better quality of innovation that able to disrupt markets then this may lead to better firm performance.

5.4. Limitation of the Study and Future Research Direction

This section describes several limitations that must be considered when interpreting the results of this thesis and proposes recommendation for future studies direction.

5.4.1. Chapter 2 - The first paper

This study has several limitations that need to be admitted. First, this study only focus in one period of innovation survey and it becomes a severe limitation of the study. Therefore, the future study should address

this limitation by employing longitudinal study to portray the change of KSS and innovation barriers over time. Secondly only small number of countries used in this study. In the future study, high number of countries can be used to perform causality analysis, e.g. using multiple regression analysis, of knowledge sourcing strategies across high- and middle-income countries. Lastly, this study only focuses on manufacturing firms, in the future studies comparing between manufacture and service firms may provide more interesting findings.

5.4.2. Chapter 3 - The second paper

The followings are limitations of the study that need to be acknowledged. First, issue on firms' sector has not been discussed in this study, as a result sectors' effect on the three links of IVC cannot be detected. Second, this study uses the IIS 2011 data that restricted covers manufacturing firms. The comparison of the IVC activities between manufacturing and service firms may provide fruitful insight and innovation policy for Indonesia. Therefore, this issue can be studied in the future works. Third, the study only portrays the Indonesian firms' IVC using data the IIS 2011, therefore the dynamics of IVC is absence from this study. A longitudinal study on the Indonesian firms' IVC may be conducted in the future.

5.4.3. Chapter 4 - The third paper

Limitation of this study is discussed with the hope that door to improve better study in the future can be opened. First, a comparison of the IVC between Indonesia and the UK that come from non-CIS and CIS countries may affect the comparison such as sectoral coverage, size thresholds, the length of reference periods, sampling methods and unit of analysis (Bloch and Lopez-Bassols, 2009). Therefore, a comparative study of the IVC among developing countries (e.g. ASEAN countries) may be conducted in the future for better and more comparable the IVC insights. Second, a longitudinal study that involves more than one innovation survey period is recommended in the future IVC studies to capture the dynamics of IVC. Third, this study uses the innovation data that restricted covers manufacturing firms. The involvement of service firms in the future studies may provide more fruitful insight. Lastly, a broader coverage of developing and developed countries need to be involved to portray and to represent how manufacturing firms in both developing and developed economies perform IVC. However, this study findings may provide early useful insight how the firms in developing and developed countries perform IVC.

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APPENDICES

Chapter 2 – Paper 1

Appendix 2.1 Kolgomorov-Smirnov (K-S) test (Sources of knowledge)

SOURCES OF KNOWLEDGE	D	P values
IN_RD	.41	.02*
GERD	.76	.00**
SUPPLIERS	.25	.34
CUSTOMERS	.18	.67
COMPETITORS	.18	.68
CONSULTANTS	.23	.40
UNIVERSITY	.28	.26
RES_INSTITUTE	.31	.16
EVENTS	.37	.05*
PUBLICATION	.46	.01**
ASSOCIATION	.31	.16

**Sig≤0.05, **Sig≤0.01*

Appendix 2.2 Kolgomorov-Smirnov (K-S) test (Innovation Barriers)

INNOVATION BARRIERS	D	P values
IN_FUNDING	.47	.01*
EX_FUNDING	.40	.07
HIGH_COST	.37	.08
PERSONNEL	.43	.02*
TECH_INFO	.53	.00**
MKT_INFO	.50	.01*
COOPERATION	.52	.00**
MKT_DOMINATION	.58	.00**
UNCER_DEMAND	.38	.07
PRIOR_INNOV	.65	.00**
NO_DEMAND	.63	.00**

**Sig≤0.05, **Sig≤0.01*

Appendix 2.3 Kolgomorov-Smirnov (K-S) test (Innovation Outputs)

INNOVATION OUTPUTS	D	P values
PRODINN	.38	.04*
PROCINN	.32	.11
PATENT	.56	.00***

**Sig≤0.05, **Sig≤0.01*

Appendix 2.4 List of countries and their groups

NO	COUNTRY	CODE	GROUP	NO	COUNTRY	CODE	GROUP
1	Australia	AUS	HI	27	Argentina	ARG	UMI
2	Austria	AUT	HI	28	Brazil	BRA	UMI
3	Belgium	BEL	HI	29	Bulgaria	BGR	UMI
4	Croatia	HRV	HI	30	China	CHN	UMI
5	Cyprus	CYP	HI	31	Colombia	COL	UMI
6	Czech Rep.	CZE	HI	32	Cuba	CUB	UMI
7	Estonia	EST	HI	33	Ecuador	ECU	UMI
8	Finland	FIN	HI	34	Egypt	EGY	LMI
9	France	FRA	HI	35	El Salvador	SLV	LMI
10	Germany	DEU	HI	36	Ghana	GHA	LMI
11	Hungary	HUN	HI	37	India	IND	LMI
12	Israel	ISR	HI	38	Indonesia	IDN	LMI
13	Italy	ITA	HI	39	Lithuania	LTU	UMI
14	Japan	JPN	HI	40	Malaysia	MYS	UMI
15	Latvia	LVA	HI	41	Mexico	MEX	UMI
16	Luxembourg	LUX	HI	42	Morocco	MAR	LMI
17	Malta	MLT	HI	43	Nigeria	NGA	LMI
18	Netherlands	NLD	HI	44	Panama	PAN	UMI
19	New Zealand	NZL	HI	45	Philippines	PHL	LMI
20	Norway	NOR	HI	46	Poland	POL	UMI
21	Portugal	PRT	HI	47	Romania	ROM	UMI
22	Rep. of Korea	KOR	HI	48	Russian Fed.	RUS	UMI
23	Slovakia	SVK	HI	49	Serbia	SRB	UMI
24	Spain	ESP	HI	50	South Africa	ZAF	UMI
25	Sweden	SWE	HI	51	Turkey	TUR	UMI
26	UK & NI	GBR	HI	52	Ukraine	UKR	LMI
				53	Uruguay	URY	UMI

World Bank classification of countries that is based on GNI per capita is used for grouping the countries. The classification is divided by four (1) *high income group (HI)*: countries that have GNI per capita USD 12,616 or more, (2) *upper middle income group (UMI):* countries that have GNI per capita USD 4,086 to 12,615, (3) *lower middle income group (LMI):* countries that have GNI per capita USD 1,036 to 4,085, and (4) *lower income group (LI):* countries that have GNI per capita USD 1,035 or less

Appendix 3.1 Correlation outputs between productivity, innovation and sources of knowledge

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.PRODUCTVITY	1																
2.INN_SUCCESS	-.036	1															
3.PRODINOV	-.016	.252	1														
4.PRODINN_N2M	.012	.574	.228	1													
5.PRODINOV_N2F	.011	-.275	.898	.041	1												
6.PROCINOV	.066	-.032	-.018	.043	.041	1											
7.ORGINOV	.084	-.091	.025	.037	-.043	.168	1										
8.MKTGINOV	-.092	-.013	-.040	.040	.066	.100	.240	1									
9.INT_RD	.053	.008	.139	-.053	-.050	.233	.321	.166	1								
10.EXT_RD	.036	.012	-.085	.045	.082	.029	.054	-.057	.086	1							
11.SUPPLIER	-.022	-.018	-.014	-.001	.008	-.007	-.036	.006	.006	.002	1						
12.CUSTOMER	.037	.046	.114	-.086	-.036	.037	-.037	.279	-.096	.007	.048	1					
13.COMPETITOR	-.0002	-.012	-.040	.089	.026	.099	-.011	.129	-.057	.007	.001	.307	1				
14.CONSULTANT	.011	-.039	.020	.015	-.011	-.053	.001	.019	.021	-.032	-.001	-.069	.070	1			
15.COMMLAB	.028	.033	-.034	-.010	.047	.045	-.009	.001	.004	.005	.070	-.022	.016	.283	1		
16.UNIVERSITY	-.060	-.008	-.042	.029	.042	-.059	-.018	.023	.076	-.041	-.012	.014	-.033	.012	.175	1	
17.POLYTECHNIC	.063	.040	.036	-.035	-.029	-.076	.025	-.004	.005	.056	.013	-.045	.018	.047	.030	.284	1
18.GOV_RD	-.021	.010	-.062	.022	.047	.052	-.031	-.011	.016	-.060	-.015	.005	-.018	.005	.103	.128	.275
19.NPROFIT_RD	.008	.044	-.005	.002	-.018	.082	-.047	.024	.003	.098	-.011	.063	-.027	.068	.032	.082	.097
20.INVESTOR	-.014	-.022	-.006	.002	.033	.072	.050	-.045	-.039	.054	.020	.032	.011	.033	-.030	.082	-.083
21.IND_ASSOC.	.114	.022	.076	-.077	-.069	-.023	.018	.002	.018	-.029	-.005	.006	.016	.126	-.013	.107	-.004
22.ENTREP	-.017	-.026	-.027	.006	.014	.001	.041	-.051	.135	-.044	-.010	.130	.087	.019	.051	-.041	.091
23.EVENTS	.036	-.001	.012	.061	.014	.022	.025	.007	-.074	-.007	.037	.067	.058	-.013	-.022	.023	-.033
24.SCIENCE_PUB	-.044	-.016	-.048	.016	.045	.006	-.050	.011	.019	-.007	-.046	.100	.051	.048	.081	-.066	.178
25.INTERNET	-.082	.026	.007	.003	-.019	.013	.083	-.035	.121	.018	.022	.143	-.060	.083	-.035	-.039	.066
26.COOP_GROUP	.048	-.043	.017	.077	-.043	.007	-.012	-.031	.054	.194	-.022	.031	-.025	-.029	.119	.006	-.056
27.COOP_SUPP	-.010	.054	.038	-.050	-.014	.021	-.002	.097	-.021	.307	.027	-.053	-.025	.026	.013	.023	-.028

28.COOP_COMPET	-.056	.022	-.048	-.030	.061	.021	.065	-.068	.027	-.076	.010	.031	.058	.034	-.032	-.074	.098
29.COOP_CONSUL	.071	-.029	-.021	.065	-.022	.029	.007	.009	-.002	-.045	.012	002	-.031	.159	-.106	-.066	.004
30.COOP_LAB	-.017	.004	.032	-.051	-.004	.005	.026	-.048	-.050	.040	-.054	.000	.069	.113	.065	.014	-.003
31.COOP_UNIV	-.039	.005	-.009	-.016	.028	.032	.024	-.001	-.035	.053	.009	-.028	-.020	.030	-.023	.187	-.065
32.COOP_GOVRD	.003	.004	.021	-.017	-.023	-.014	-.056	.063	.048	.051	.022	-.045	.026	.002	.028	.010	-.063
33.COOP_ASSOC	-.041	-.030	.090	-.046	-.074	-.014	-.0003	.045	.030	.020	.004	-.051	.056	-.129	.094	.031	-.028

Notes: Significant levels *** 1% (p<.01), ** 5% (p<.05), 10% (* p<.10)

Appendix 3.1 Correlation outputs between innovation, innovation success and sources of knowledge (Continued)

VARIABLES	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
18.GOV_RD	1															
19.NPROFIT_RD	.333	1														
20.INVESTOR	.193	-.019	1													
21.IND_ASSOC.	.087	.029	.113	1												
22.ENTREP	-.055	-.003	.289	.080	1											
23.EVENTS	.054	.035	-.024	.132	.184	1										
24.SCIENCE_PUB	-.026	.084	.037	.086	-.040	.323	1									
25.INTERNET	.039	-.048	.023	.097	.153	.058	-.022	1								
26.COOP_GROUP	.014	-.021	-.029	.038	.033	-.007	.052	-022	1							
27.COOP_SUPP	-.011	-.061	.005	-.008	.047	-.026	.022	.034	.249	1						
28.COOP_COMPET	-.074	.090	.011	.064	.007	-.033	-.061	-.068	-098	.341	1					
29.COOP_CONSUL	.030	-.035	-.016	-.040	-.008	.028	.010	.050	.234	.191	.130	1				
30.COOP_LAB	-.042	-.007	.033	-.055	.010	-.048	-.004	-.039	.001	-.007	.079	.097	1			
31.COOP_UNIV	-.033	.027	.004	-.020	.010	.071	-.066	-.010	-.035	.028	-.119	.291	.149	1		
32.COOP_GOVRD	.109	-.090	-.004	-.028	-.006	-.012	.009	.084	.070	-.127	.334	.009	.110	.415	1	
33.COOP_ASSOC	-.016	-.029	.050	.075	-.060	-.029	.020	.041	.139	-.141	.239	.176	.055	.103	-.221	1

Notes: Significant levels *** 1% (p<.01), ** 5% (p<.05), 10% (* p<.10)

Appendix 3.2 Component Loadings for Innovation Barriers

VARIABLE	FACTOR1	FACTOR2	FACTOR3	FACTOR4
INFUND	-.067	**.476**	.015	.099
EXFUND	-.065	**.476**	.005	.087
COST	.033	**.502**	.002	-.066
RISK	.090	**.487**	-.045	-.118
STAFF_RESIST	-.040	.051	**.519**	-.004
MANAGER_RESIST	.009	-.002	**.564**	-.054
ORGRIGID	.039	-.072	**.520**	.017
PERSONNEL	-.073	.019	.251	**.336**
TECH_INFO	-.052	.030	-.035	**.557**
MARKET_INFO	.048	-.086	-.020	**.543**
COOPERATION	.048	.141	-.073	**.366**
LABOUR	.129	.015	.163	.223
MKT_DOMINATION	**.400**	-.021	-.067	.014
UNCER_DEMAND	**.394**	-.013	-.063	.084
CUSTOMER	**.413**	-.107	-.108	.150
INFRASTRUCTURE	**.334**	.067	.023	.023
STANDARD	**.413**	.058	.102	-.111
GOVREG	**.427**	.040	.111	-.132
Eigenvalue	7.866	1.632	1.226	1.063
Cronbach's alpha			.924	
Kaiser-Meyer-Olkin			.917	
Percentage of total variance explained			65.50	

Factor 1: Barriers related to "market and institutions"
Factor 2: Barriers related to "financial and risk"
Factor 3: Barriers related to "employee and organisation"
Factor 4: Barriers related to "knowledge and cooperation"

Appendix 4.1 Definition of Assessed Variables

NO	VARIABLES	DEFINITION
1	**FIRM PERFORMANCE**	
1.1	*Productivity*	*Total sales/number of employee (Indonesia=IDR; UK=£)*
2	**INNOVATION PERFORMANCE**	
2.1	*INNSUCCES*	*Proportion sales of product innovation that new to the market (%)*
3	**TYPES OF INNOVATION**	
3.1	*PRODINOV*	*Product innovation (0/1)*
3.2	*PRODINOV_MARKET*	*Product innovation that new to the market (0/1)*
3.3	*PRODINOV_FIRM*	*Product innovation that new to the firms (0/1)*
3.4	*PROCINOV*	*Process innovation (0/1)*
3.5	*ORGINOV*	*Organisational innovation (0/1)*
3.6	*MKTGINOV*	*Marketing innovation (0/1)*
4	**SOURCES OF KNOWLEDGE**	
4.1	**R&D ACTIVITIES**	
4.1.1	*INTERNAL_RD*	*Internal (in-house) research and development (0/1)*
4.1.2	*EXTERNAL_RD*	*External research and development (0/1)*
4.2	**INFORMAL KNOWLEDGE**	
	Market & commercials (highly important)	
4.2.1	*SUPPLIERS*	*Suppliers of equipment, materials, services or software (0/1)*
4.2.2	*CUSTOMERS*	*Clients or customers (0/1)*
4.2.3	*COMPETITORS*	*Competitors or other business in your industry (0/1)*
4.2.4	*CONSULTANTS*	*Consultants, commercials labs or private R&D institutes (0/1)*
	Scientific institutions (highly important)	
4.2.5	*UNIVERSITIES*	*Universities or other higher education institutions (0/1)*
4.2.6	*GOV_RD*	*Government or public research institutes (0/1)*
	Associations (highly important)	
4.2.7	*IND_ASSOC*	*Industry associations (0/1)*
	Open sources (highly important)	
4.2.8	*EVENTS*	*Conferences, trade fairs, exhibitions (0/1)*
4.2.9	*SCIENCE_PUB*	*Scientific journals and trade/technical publications (0/1)*
4.3	**FORMAL COOPERATION**	
4.3.1	*COOP_FIRMGROUP*	*Formal cooperation within firms' groups (0/1)*
4.3.2	*COOP_SUPPLIERS*	*Formal cooperation with suppliers (0/1)*

4.3.3	*COOP_COMPET*	*Formal cooperation with competitors (0/1)*
4.3.4	*COOP_CONSUL*	*Formal cooperation with consultants (0/1)*
4.3.5	*COOP_UNIV*	*Formal cooperation with universities (0/1)*
4.3.6	*COOP_GOVRD*	*Formal cooperation with public or government R&D institutions (0/1)*
5	**INNOVATION BARRIERS**	
	Financial barriers (highly important)	
5.1	*INBAR_HIGHRISK*	*Innovation barrier: Excessive risk (0/1)*
5.2	*INBAR_ECONRISK*	*Innovation barrier: Excessive perceived economic risk (0/1)*
5.3	*INBAR_HIGHCOST*	*Innovation barrier: Direct innovation cost too high (0/1)*
5.4	*INBAR_INFUND*	*Innovation barrier: Lack of internal funding (0/1)*
5.5	*INBAR_EXFUND*	*Innovation barrier: Lack of external funding (0/1)*
5.6	*INBAR_COSTFIN*	*Innovation barrier: Cost of finance (0/1)*
5.7	*INBAR_FINAVAILABLE*	*Innovation barrier: Availability of finance (0/1)*
	Knowledge barriers (highly important)	
5.8	*INBAR_PERSON*	*Innovation barrier: Lack of qualified personnel (0/1)*
5.9	*INBAR_TECHINFO*	*Innovation barrier: Lack of information on technology (0/1)*
5.10	*INBAR_MKTINFO*	*Innovation barrier: Lack of information on market (0/1)*
	Market barriers (highly important)	
5.11	*INBAR_MKTDOM*	*Innovation barrier: Market dominated by established firms (0/1)*
5.12	*INBAR_UNCERDEMAND*	*Innovation barrier: Uncertainty demand for innovation (0/1)*
	Institutional barriers (highly important)	
5.13	*INBAR_GOVREG*	*Innovation barrier: Lack of ability to meet government regulations (0/1)*

6	**FIRM RESOURCES**	
6.1	*EMPLOYMENT*	*Firm size (number of employee)*
6.2	*EXPORT*	*Proportion of export from total sales (%)*
	Employee quality	
6.3	*EDU_UNDERHIGHSCHOOL*	*Proportion of employee hold degree: under high schools (%)*
6.4	*EDU_HIGHCHOOL*	*Proportion of employee hold degree: high schools (%)*
6.5	*EDU_DIPLOMA*	*Proportion of employee hold degree: diploma (%)*
6.6	*EDU_UNDERGRAD*	*Proportion of employee hold degree: under graduate (%)*
6.7	*SCIENCE_DEGREE*	*Proportion of employee hold degree: science subjects (%)*
6.8	*OTHER_DEGREE*	*Proportion of employee hold degree: other subjects (%)*
	Technology intensity	
6.9	*HIGH_TECH*	*Firms classified as high technology (0/1)*
6.10	*MEDHIGH_TECH*	*Firms classified as medium to high technology (0/1)*
6.11	*MEDLOW_TECH*	*Firms classified as medium to low technology (0/1)*
6.12	*LOW_TECH*	*Firms classified as low-technology (0/1)*

Appendix 4.2 Comparison Variables: IIS 2011 versus UKIS 2011

NO	IIS 2011	UKIS 2011
1	**FIRM PERFORMANCE**	**FIRM PERFORMANCE**
1.1	*Productivity (sales/number of employee)*	*Productivity (sales/number of employee)*
2	**INNOVATION PERFORMANCE**	**INNOVATION PERFORMANCE**
2.1	*INNSUCCESS (% of PRODINOV_NEW2MARKET)*	*INNSUCCESS (% of PRODINOV_NEW2MARKET)*
3	**TYPES OF INNOVATION**	**TYPES OF INNOVATION**
3.1	*PRODINOV (0/1)*	*PRODINOV (0/1)*
3.2	*PRODINOV_MARKET (0/1)*	*PRODINOV_MARKET (0/1)*
3.3	*PRODINOV_FIRM (0/1)*	*PRODINOV_FIRM (0/1)*
3.4	*PROCINOV (0/1)*	*PROCINOV (0/1)*
3.5	*ORGINOV (0/1)*	*ORGINOV (0/1)*
3.6	*MKTGINOV (0/1)*	*MKTGINOV (0/1)*
4	**SOURCES OF KNOWLEDGE**	**SOURCES OF KNOWLEDGE**
4.1	**R&D ACTIVITIES**	**R&D ACTIVITIES**
4.1.1	*INTERNAL_R&D*	*INTERNAL_R&D*
4.1.2	*EXTERNAL_R&D*	*EXTERNAL_R&D*
4.2	**INFORMAL KNOWLEDGE**	**INFORMAL KNOWLEDGE**
	Market & commercials (highly important)	**Market & commercials (highly important)**
4.2.1	*SUPPLIERS (0/1)*	*SUPPLIERS (0/1)*
4.2.2	*CUSTOMERS (0/1)*	*CUSTOMERS (0/1)*
4.2.3	*COMPETITORS (0/1)*	*COMPETITORS (0/1)*
4.2.4	*CONSULTANTS (0/1)*	*CONSULTANTS (0/1)*
	Scientific institutions (highly important)	**Scientific institutions (highly important)**
4.2.5	*UNIVERSITIES (0/1)*	*UNIVERSITIES (0/1)*
4.2.6	*GOV_RD (0/1)*	*GOV_RD (0/1)*
	Associations (highly important)	**Associations (highly important)**

4.2.7	*INDUSTRY_ASSOC (0/1)*	*INDUSTRY_ASSOC (0/1)*
	Open sources (highly important)	**Open sources (highly important)**
4.2.8	*EVENTS (0/1)*	*EVENTS (0/1)*
4.2.9	*SCIENCE_PUB (0/1)*	*SCIENCE_PUB (0/1)*
4.3	**FORMAL COOPERATION**	**FORMAL COOPERATION**
4.3.1	*COOP_FIRMGROUP (0/1)*	*COOP_FIRMGROUP (0/1)*
4.3.2	*COOP_SUPPLIERS (0/1)*	*COOP_SUPPLIERS (0/1)*
4.3.3	*COOP_COMPETITORS (0/1)*	*COOP_COMPETITORS (0/1)*
4.3.4	*COOP_CONSULTANTS (0/1)*	*COOP_CONSULTANTS (0/1)*
4.3.5	*COOP_UNIVERSITIES (0/1)*	*COOP_UNIVERSITIES (0/1)*
4.3.6	*COOP_GOVRD (0/1)*	*COOP_GOVRD (0/1)*
5	**INNOVATION BARRIERS**	**INNOVATION BARRIERS**
	Financial barriers (highly relevant)	**Financial barriers (highly relevant)**
5.1	*INBAR_HIGHRISK (0/1)*	*INBAR_ECONRISK(0/1)*
5.2	*INBAR_HIGHCOST (0/1)*	*INBAR_HIGHCOST (0/1)*
5.3	*INBAR_INFUND (0/1)*	*INBAR_COSTFIN (0/1)*
5.4	*INBAR_EXFUND (0/1)*	*INBAR_COSTAVAILABLE*
	Knowledge barriers (highly relevant)	**Knowledge barriers (highly relevant)**
5.5	*INBAR_PERSON (0/1)*	*INBAR_PERSON (0/1)*
5.6	*INBAR_TECHINFO (0/1)*	*INBAR_TECHINFO (0/1)*
5.7	*INBAR_MARKETINFO (0/1)*	*INBAR_MARKETINFO (0/1)*

	Market barriers (highly relevant)	**Market barriers (highly relevant)**
5.8	*INBAR_MKTDOM (0/1)*	*INBAR_MKTDOM (0/1)*
5.9	*INBAR_UNCERDEM) (0/1)*	*INBAR_UNCERDE) (0/1)*
	Institutional barriers (highly relevant)	**Institutional barriers (highly relevant)**
5.10	*INBAR_GOVREG (0/1)*	*INBAR_GOVREG)(0/1)*
6	**FIRM RESOURCES**	**FIRM RESOURCES**
6.1	*EMPLOYMENT (number of employee)*	*EMPLOYMENT (number of employee)*
6.2	*EXPORT (%)*	*EXPORT (%)*
	Employee quality	**Employee quality**
6.3	*UNDERGRAD (%)*	*SCIENCE_DEGREE (%)*
		OTHER_DEGREE (%)
	Technology intensity	**Technology intensity**
6.4	*LOWTECH (0/1)*	*LOW_TECH (0/1)*
6.5	*MEDLOW_TECH (0/1)*	*MEDLOW_TECH (0/1)*
6.6	*MEDHIGH_TECH (0/1)*	*MEDHIGH_TECH (0/1)*
6.7	*HIGH_TECH (0/1)*	*HIGH_TECH (0/1)*

Appendix 4.3.1 Variable correlation: INDONESIA (1179 firms)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.PRODUCTIVITY	1																		
2.INNSUCCESS	-.03	1																	
3.PRODINOV	-.02	.25	1																
4.PRODINOV_MKT[1]	.01	.57	.23	1															
5.PRODINOV_FIRM[2]	.02	-.28	.90	.05	1														
6.PROCINOV	.07	-0.03	-.04	.06	.05	1													
7.ORGINOV	.08	-.10	.03	.04	-.05	.19	1												
8.MKTGINOV	-.08	-.02	-.06	.08	.06	.07	.24	1											
9.IN_RD	.03	.02	.14	-.07	-.04	.24	.35	.17	1										
10.EX_RD	.05	.01	-.08	.06	.07	.04	.05	-.07	.09	1									
11.SUPPLIERS	-.02	-.01	-.02	.002	.01	-.003	-.04	.01	.01	.004	1								
12.CUSTOM	.03	.04	.08	-.04	-.03	.02	.01	.20	-.02	-.009	.05	1							
13.COMPET	.01	-.04	-.04	.12	.02	.07	.01	.08	-.05	-.01	.01	.25	1						
14.CONSUL	-.02	.02	-.03	.0003	.05	.02	.01	.01	.02	-.01	.03	-.02	.07	1					
15.UNIV	.03	.03	.01	-.01	-.01	-.10	.02	.02	.07	.03	-.0004	-.02	.03	.19	1				
16.GOV_RD	-.01	.03	-.09	.05	.06	.08	-.04	-.03	.03	-.02	-.002	.01	-.07	.14	.35	1			
17.IND_ASSOC	.11	.003	.08	-.05	-.08	-.02	.03	-.02	.05	-.04	.003	.04	-.01	.10	.10	.12	1		
18.EVENTS	.04	-.004	-.01	.08	.03	.02	.05	-.02	-.03	-.02	.05	.09	.04	-.01	.01	.06	.16	1	
19.SCIENCE_PUB	-.03	-.005	-.05	.01	.05	-.004	-.05	.004	.01	.01	-.04	.09	.05	.11	.09	.04	.09	.31	1

Note: [1]Product innovation new to the market; [2] Product innovation new to the firm

Appendix 4.3.1 Variable correlation: INDONESIA (1179 firms) *(continued)*

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20.COOP_FIRMGROUP	.040	-.05	.02	.08	-.04	.01	-.02	-.03	.07	.20	-.02	.03	-.003	.06	-.03	.01	.05	-.001	.05
21.COOP_SUPP.	-.003	.06	.03	-.04	-.01	.03	.002	.10	-.01	.30	.03	-.03	-.02	.01	-.02	-.02	-.004	-.004	.02
22.COOP_COMPET.	-.054	.02	-.03	-.04	.05*	.01	.06**	-.07	.02	-.06	.01	.005	.07	-.03	.03	-.05	.07	-.06	-.05
23.COOP_CONSUL.	.06	-.03	.04	.00	-.05*	.03	.03	.01	-.02	-.03	-.01	.02	.003	.14	-.10	.01	-.02	.02	.01
24.COOP_UNIV.	-.06	-.01	-.01	-.007	.03	.04	.02	.001	-.04	.05*	.01	-.04	-.02	-.01	.17	-.06	-.01	.06	-.09
25.COOP_GOVRD	-.0002	.02	.01	-.02	-.01	-.01	-.04	.06	.04	.05*	.01	-.02	.04	.01	-.05	.09	-.03	.001	-.004
26.INBAR_HIGHRISK	.03	.05	.02	-.02	-.01	.04	-.09	.07	-.01	-.02	.003	.09	.04	.04	-.03	-.07	-.03	.0002	-.03
27.INBAR_HIGHCOST	.02	-.02	.03	.01	-.02	.05*	-.04	.04	.06	-.02	.003	-.04	.02	-.01	-.01	.03	.01	-.01	.09
28.INBAR_INFUND	-.02	-.05	-.02	.03	.03	.03	-.04	.01	-.08	.01	.003	.14	.01	-.08	.07	.02	-.08	.03	-.03
29.INBAR_EXFUND	-.03	.10	-.01	-.13	.03	-.04	.10	.07	-.09	.07	.003	.01	.03	-.02	-.02	.01	.07	-.0001	.01
30.INBAR_PERSON	.02	-.05	.07	-.07	-.01	.02	-.05	.07	.04	-.05	.04	.03	-.03	.05*	0.02	.08	.01	-.02	-.05
31.INBAR_TECHINFO	-.02	-.01	-.0001	-.01	.02	.02	.02	-.05	.01	.02	.03	-.05	.01	-.02	.001	-.004	.04	-.04	.06
32.INBAR_MKTINFO	-.04	.005	-.05	.02	.04	-.02	-.06	-.004	.05*	.04	-.04	.04	.10	-.01	.03	-.001	.10	.07	-.05
33.INBAR_MKTDOM	-.03	-.004	.02	-.05	.0004	.06	.02	.04	-.01	.05*	-.01	.03	.06	.03	-.04	.03	.09	.01	.001
34.INBAR_UNDEMAND	.02	.06	.005	-.05	-.01	-.002	.04	-.02	.001	-.01	-.03	-.002	.08	-.05	.01	.08	.02	.01	-.08
35.INBAR_GOVREG	-.01	-.02	.09	.01	-.1	.05	-.01	.02	-.01	.01	-.03	.06**	-.004	-.01	-.05	.04	-.06	.10	.11

Appendix 4.3.1 Variable correlation: INDONESIA (1179 firms) *(continued)*

VARIABLES	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
20.COOP_FIRMGROUP	1															
21.COOP_SUPP.	.26	1														
22.COOP_COMPET.	-.07	.33	1													
23.COOP_CONSUL.	.23	.16	.18	1												
24.COOP_UNIV.	.01	.03	-.09	.32	1											
25.COOP_GOVRD	.05	-.10	.31	-.01	.44	1										
26.INBAR_HIGHRISK	.06	-.04	.01	-.01	-.01	.01	1									
27.INBAR_HIGHCOST	-.02	-.03	.02	-.01	.03	.43	.43	1								
28.INBAR_INFUND	-.05	.03	-.03	.05*	-.03	.04	.16	.16	1							
29.INBAR_EXFUND	.02	-.02	.01	-.04	-.005	.09	.14	.51	.51	1						
30.INBAR_PERSON	.03	-.02	-.05	-.003	-.02	-.08	.03	.11	.11	.07	1					
31.INBAR_TECHINFO	-.07	.07	-.03	-.02	.004	.02	.04	-.004	-.004	.07	.24	1				
32.INBAR_MKTINFO	-.07	.05	-.01	.01	.02	-.02	-.02	.05	.05	.03	.15	.23	1			
33.INBAR_MKTDOM	.03	-.06	.09	-.03	-.02	.12	.002	.09	.09	-.05	.06	.05	.05	1		
34.INBAR_UNDEMAND	-.03	.01	-.05	.001	.04	.10	.05	.03	.03	-.01	.03	.15	.04	.28	1	
35.INBAR_GOVREG	.01	-.04	.10	-.05*	.02	.04	.03	.06	.06	.01	.14	.05	.08	.07	.12	1

Appendix 4.3.2 Variable Correlations: THE UK (2133 Firms)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.PRODUCTIVITY	1																		
2.INNSUCCESS	-.01	1																	
3.PRODINOV	.03	.04	1																
4.PRODINOV_MKT[1]	.01	.43	.42	1															
5.PRODINOV_FIRM[2]	-.05	-.09	.66	-.18	1														
6.PROCINOV	.07	.005	.08	.03	.02	1													
7.ORGINOV	-.01	-.02	.02	.01	-.03	.17	1												
8.MKTGINOV	-.03	.02	-.004	.04	.05	.05	.21	1											
9.INTERNAL_RD	-.01	.02	.17	.06	.00	.04	.07	.09	1										
10.EXTERNAL_RD	.03	-.01	-.03	.09	.07	.01	.05	-.01	.19	1									
11.SUPPLIERS	-.04	.02	-.02	-.02	.02	.09	.05	.06	.004	-.01	1								
12.CUSTOMERS	-.01	-.003	.09	.04	.04	.02	.06	-.04	.15	-.01	.14	1							
13.COMPETITORS	.05	-.01	.03	-.02	.01	-.04	-.01	.02	.03	-.01	.05	.24	1						
14.CONSULTANTS	.09	.03	.01	.02	-.02	-.03	.04	-.01	-.01	.04	.15	-.02	.06	1					
15.UNIVERSITIES	.04	.03	-.02	.01	-.001	.02	-.01	.004	.01	.01	-.03	.004	-.01	.21	1				
16.GOV_RD	-.02	.02	-.04	.04	.02	.01	-.03	.02	-.01	-.06	.03	.02	.03	.10	.21	1			
17.EVENTS	.03	-.02	-.04	-.02	-.01	.003	.03	.05	-.02	.01	.09	.06	.11	-.01	.07	.12	1.		
18.IND_ASSOC.	-.07	.03	-.05	.06	.03	.05	-.02	.005	.005	.02	-.03	.04	.14	.08	-.03	.03	.23	1	
19.SCIENCE_PUB	.001	.06	-.03	-.06	.02	.02	.004	.04	.02	.02	-.01	-.01	.05	.02	.06	.0002	.17	.23	1

Note: [1] Product innovation new to the market; [2] Product innovation new to the firm

Appendix 4.3.2 Variable Correlations: THE UK (2133 Firms) *(continued)*

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20.COOP_FIRMGROUP	.13	-.04	.05	.01	-.01	.13	.07	-.03	.001	.04	-.06	.06	.01	-.004	-.07	.04	.07	.03	-.004
21.COOP_SUPP.	.002	.10	.02	-.02	.06	.05	.06	.06	.06	.05	.21	.05	-.01	-.06	.03	-.02	-.05	.003	-.01
22.COOP_COMPET.	-.05	.04	-.01	.07	.05	-.05	-.01	.05	-.004	-.02	-.02	-.02	.08	-.001	.05	-.03	.07	-.02	.05
23.COOP_CONSUL	-.01	.001	.05	-.04	-.06	-.02	.03	.06	.05	.16	.002	-.01	.04	.25	-.08	.01	-.01	-.02	.05
24.COOP_UNIV.	.04	-.05	-.02	.04	.02	.04	-.05	.005	.06	.11	-.02	.05	-.01	-.08	.26	-.08	-.03	.03	.02
25.COOP_GOVRD	.01	.002	-.03	.03	.03	-.004	.01	-.05	-.03	-.04	-.04	-.02	.02	.01	-.03	.22	.11	-.06	-.06
26.INBAR_ECONRISK	-.04	-.04	.03	-.03	-.03	.004	.02	-.03	.02	.08	.08	-.05	.02	-.03	-.01	.001	-.02	.03	.02
27.INBAR_HIGHCOST	.01	.01	.03	-.01	.02	-.01	.03	-.03	-.04	-.05	.01	-.02	.05*	-.02	.03	-.02	.01	-.01	.02
28.INBAR_COSTFIN	-.02	-.01	-.01	.002	-.003	.005	-.02	.04	-.01	-.02	.05	-.005	.01	-.01	.01	.01	.002	.003	.06
29.INBAR_FINABLE	-.06	.04	-.01	-.004	.03	-.02	.04	.0001	-.02	-.02	-.01	.02	-.04	.07	.01	-.04	-.01	-.001	-.05
30.INBAR_PERSON	-.01	.04	-.004	-.01	.07	.01	.01	.005	-.0003	-.01	-.01	.01	-.01	-.03	.04	-.04	-.09	-.02	.02
31.INBAR_TECHINFO	.01	.01	-.02	.01	-.03	.02	.03	-.02	.01	-.04	-.003	.02	-.02	.06	.001	-.02	.04	.03	-.07
32.INBAR_MKTINFO	-.01	-.04	-.01	-.002	.02	.02	.03	.04	-.01	.01	.01	-.01	.03	-.05	-.02	.002	.03	.002	.03
33.INBAR_MKTDOM	-.01	.04	-.03	-.04	.01	-.03	.01	-.01	-.01	.01	-.01	-.02	.05	-.03	-.04	.02	-.01	.04	.01
34.INBAR_UNDEMAND	.07	-.004	-.07	.02	.06	-.04	-.06	.02	.02	.05	-.01	-.01	.01	.0002	.02	.02	-.02	.02	-.03
35.INBAR_GOVREG	.005	.01	.04	.02	-.03	-.03	-.03	.022	.02	-.02	.001	-.02	.03	.04	-.06	.10	.07	.01	-.01

Appendix 4.3.2 Variable Correlations: THE UK (2133 Firms) *(continued)*

VARIABLES	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
20.COOP_FIRMGROUP	1															
21.COOP_SUPP.	.25	1														
22.COOP_COMPET.	.14	.07	1													
23.COOP_CONSUL.	.01	.19	.07	1												
24.COOP_UNIV.	.09	-.01	.09	.20	1											
25.COOP_GOVRD	.06	.06	.20	.22	.28	1										
26.INBAR_ECONRISK	-.002	-.05	.01	-.03	.01	.04	1									
27.INBAR_HIGHCOST	-.001	.001	.01	.02	-.02	-.01	.34	1								
28.INBAR_COSTFIN	.03	-.01	-.05	.02	-.01	-.005	.05	.15	1							
29.INBAR_FINABLE	-.02	.01	-.01	-.03	.03	.02	.06	.02	.62	1						
30.INBAR_PERSON	.01	.02	.02	-.01	-.01	.04	.01	.07	.08	-.08	1					
31.INBAR_TECHINFO	-.01	-.002	-.05	.04	-.05	.03	.06	.01	.04	-.03	.30	1				
32.INBAR_MARKETINFO	.01	-.03	.06	.08	.03	-.08	.02	.06	-.06	.10	.06	.21	1			
33.INBAR_MKTDOM	.002	-.03	-.01	.01	.06	-.04	.02	.04	-.002	.02	.10	.04	.05	1		
34.INBAR_UNDEMAND	.05	-.02	.003	.03	-.04	-.0002	.13	.08	.01	.02	.04	.05	.02	.19	1	
35.INBAR_GOVREG	-.03	.06	-.01	-.005	.05	-.02	.12	.07	.01	.05	.07	.06	-.02	.04	.07	1